BRITISH STANDARD

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Specification for

Direct-acting electrical recording instruments and their accessories

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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
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Electric Cable Makers' Confederation
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Electronic Engineering Association
Engineering Equipment Users' Association*
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Oil Companies' Materials Association
Post Office*
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The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard.

British 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)

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Contents

Foreword

This British Standard has been prepared under the authority of the Electrical Industry Standards Committee. Wherever possible it is based on IEC Publication 258 *"Direct recording electrical measuring instruments and their accessories"*.

Apart from changes in format, the chief differences between this revision and the previous one lies in the performance classification of recorders. In accordance with international practice the concept of class accuracy has been used throughout; the performance of recorders is characterized by a number, termed the class index, which designates the upper limit of instrument error, expressed in percent, when the instrument is used under reference conditions. Further, errors in recording are related, not to the maximum scale value as in the previous edition, but to a "fiducial value" which is clearly defined for each type of recorder.

Under the class index system of classification the permitted changes of error with varying influence quantities — ambient temperature, position, frequency, external magnetic field, etc. — are implicit in the classification, and consequently it has not been necessary as in the past to include tables of the variations of error permitted for each influence quantity for each kind of recorder.

A further change, which has been made in order to assist the user to decide whether a recorder is suitable for his purpose, is the introduction of a list of recommended symbols which are to be marked on the instrument. These symbols indicate not only the types of measuring element and chart-driving mechanism, but also the measuring class index, the time-keeping class index, the test voltage and other relevant information.

The effect of pen-to-paper friction has, as previously, been excluded in determining the errors of recording, but this revision requires that the friction effect shall be determined, where applicable, in a specified manner, and useful information on the subject is given in an appendix.

Instruments of the indirect acting type, in which the indicating or marking device is driven by a motor or other device controlled electromagnetically or electronically by the measured quantity, are covered by BS 5164 "*Indirect-acting electrical indicating and 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 to iv, pages 1 to 42, an inside back cover and a back cover.

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

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1 Scope

1.1 This British Standard specifies requirements for direct-acting electrical recording instruments, which are used for recording the instantaneous, effective or mean values of one or more measured quantities as a function of time. It refers to strip, drum and disc recording instruments, such as

ammeters;

voltmeters;

single-phase and polyphase wattmeters, varmeters and phasemeters;

frequency recorders.

It applies to those recording instruments which incorporate rectifiers or diodes and to thermocouple recording instruments, also to certain accessories used with such apparatus, such as

shunts;

series resistors and impedances.

Other accessories may be associated with instruments provided that the instrument has been calibrated together with the accessory.

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

Additionally, it applies to recording instruments incorporating electronic devices in their auxiliary circuits.

1.3 The standard generally does not apply to recording instruments having electronic devices other than rectifiers or diodes in the measuring circuit.

However, at the choice of the manufacturer, recording instruments together with their non-interchangeable accessories having electronic devices other than rectifiers and diodes in the measuring circuit shall be considered as included in the scope of the present standard provided that they are marked "BS 90" and marked with the class index and the appropriate symbol from Table 17.

1.3.1 Examples include recording instruments together with non-interchangeable accessories, if any, having neither an incorporated supply source nor needing an external supply source. The electronic devices of these recording instruments are energized by the measured quantity and will, in some circumstances, be used for the protection of the recording instrument.

1.3.2 Examples also include recording instruments together with non-interchangeable accessories, if any, having an incorporated supply source, in general a battery, provided that the electronic devices are used for affecting the recorded value only, and that the voltage of the source and any voltage generated from that source do not exceed the limit of extra low voltage.

1.3.3 An external supply source is allowed when the nominal circuit voltage (circuit insulation voltage) of the measuring circuit does not exceed the limit of extra low voltage.

1.4 The standard does not apply to:

recording instruments having a square-wave response greater than 90 % of the effective range on a square wave with an amplitude equal to the effective range and a frequency of more than 5 Hz;

multi-purpose recording instruments and ohmmeters;

integrating recording instruments;

indirect-acting recording instruments;

recording instruments in which the measured quantity is presented in the form of digits, codes, punched cards etc.

recording instruments in which the chart movement is a function of a quantity other than time.

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

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

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

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 recording instrument (receiver)

an electrically operated measuring instrument used as the recording means of an electrically operated measuring equipment

2.1.2 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.

2.1.2.1
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.

2.1.2.2
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 a shunt current

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 considered to have limited interchangeability

2.1.2.3
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

2.1.3
instrument with contacts

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

2.1.4
instrument with magnetic screening

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

2.1.5
instrument with electrostatic screening

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

2.1.6
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

2.1.7
multi-purpose instrument

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

2.1.8
distortion factor

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

2.1.9
percentage ripple content

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

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

2.1.10
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

2.1.11
polyphase instrument

an instrument for the measurement of the power or reactive voltamperes or of the power factor in a balanced or unbalanced polyphase system

2.1.12
balanced-load polyphase instrument

an instrument for the measurement of the power or reactive voltamperes or of the power factor, in a balanced polyphase system

2.1.13
measured quantity input circuit

the internal circuit which is the prime factor in actuating the moving element when it is energized by a voltage or current which is a function of the measured quantity

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

2.1.14
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".

2.1.15
auxiliary circuit

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

2.1.16
auxiliary power supply

the power supply which energizes the auxiliary circuit

2.2 Description of recording instruments

2.2.1 According to the recording mechanism

2.2.1.1
integrating instrument

an instrument which records the time integral of the measured quantity

2.2.1.2
single instrument

an instrument having only one measuring element

2.2.1.3
multiple instrument

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

2.2.1.4
single-channel instrument

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

2.2.1.5
multiple-channel instrument

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

2.2.2 According to the form of chart

2.2.2.1
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

2.2.2.2
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

2.2.2.3
disc chart recording instrument

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

2.2.3 According to the method of recording

2.2.3.1
ink recording instrument

an instrument in which the record is made with ink

2.2.3.2
stylus recording instrument

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

2.2.3.3
printing instrument

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

2.2.3.4
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

2.2.4 According to the kind of record

2.2.4.1
continuous line recording instrument

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

2.2.4.2
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
recording device

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

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
chart-driving mechanism

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

2.3.1.4 Movement

2.3.1.4.1
spring-driven hand-wound clockwork

an escapement mechanism motivated by a hand-wound mainspring

2.3.1.4.2
spring-driven electrically wound clockwork

an escapement mechanism motivated by an electrically wound mainspring

2.3.1.4.3
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

2.3.1.4.4
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

2.3.1.4.5
impulse-driven motor

a device for driving the chart in predetermined increments of time

2.3.1.4.6
direct current motor

a self-starting motor supplied with direct current

2.3.1.5
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
mechanical zero adjuster

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

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

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
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
dead band

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

2.4.2
resistance of the external circuit

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

2.4.3
resistance of the input circuit

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

2.4.4 Dynamic response

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

2.4.4.1
step response time

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

2.4.4.2
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

2.4.4.3
overshoot

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

2.4.4.4
residual deflection

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

2.4.4.5
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

2.4.4.6
square-wave response

the frequency range of a square-wave measured quantity for which the instrument gives a record, the maximum values of which lie within specified limits

2.4.4.7
writing speed

the speed of the recording device relative to the chart

2.4.5
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

2.4.6
preliminary adjustments

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

2.4.7 Parasitic voltages

2.4.7.1
series mode (series voltage)

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

2.4.7.2
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

2.4.7.3
parasitic voltage interference factor

the parasitic voltage as defined according to **2.4.7.1** and **2.4.7.2**, divided by the effective range 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 recording instrument

the rated value(s) of a:

voltmeter or ammeter is (are) the value(s) corresponding to the upper limit of the effective range;

wattmeter or varmeter are the values of voltage, current and frequency which occur in the designation;

phasemeter or power factor recorder are the values of voltage, current and frequency which occur in the designation;

frequency recorder are the values of frequency and voltage which occur in the designation.

in a transformer-operated instrument, the rated values of voltage or current of the instrument are the values which occur in the designation divided by the rated transformation ratio

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 power factor of a wattmeter

the factor by which it is necessary to multiply the product of the rated voltage and rated current to obtain the rated power

NOTE $\text{Rated power factor} = \dfrac{\text{rated power}}{\text{rated voltage} \times \text{rated current}}$
$= \cos \varphi$ for sinusoidal quantities only.

In a varmeter, the rated value of $\sin \varphi$ is defined by analogy with the above expression.

2.5.5
maximum current and maximum voltage

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

2.5.6
rated chart speed

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

2.5.7
rated input values of the auxiliary power supply

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

2.5.8
rated upper limit of the frequency response

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

2.5.9
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

2.5.10
rated time per point for a multiple-channel instrument

the time between two successive measurements

2.5.11
rated duration of cycle for a multiple-channel instrument

the time taken for one cycle of the input circuit selector

2.5.12
rated dotting time for a single-channel instrument

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

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 recorded values of a 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 for frequency recorders;

d) 90 electrical degrees for phasemeters and power factor recorders;

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

f) 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

2.7.1.5
friction effect

for a continuous line recording instrument, the effect which the friction of the recording device on the chart may have on the record. Its value is expressed as a percentage of the chart scale length. Friction effect may include effects due to play and hysteresis

2.7.1.6
total error of a continuous line recorder

the difference between the recorded value and the true value. The total error arises from a combination of the error due to the measuring element and of a part of the maximum value of the friction effect which depends on the following factors: deflection, chart speed, rate of change of the measured quantity and the instant of reading

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 to 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, with respect to time-keeping is defined by the limit of intrinsic error and 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 time-keeping. It is applicable to the variation as well as to the intrinsic error

3 Classification

3.1 Recording instruments specified in this standard are classified according to:

the accuracy class related to the measured quantity (see **3.1.1**);

the accuracy class related to time-keeping (see **3.1.2**);

the method of recording (see **2.2.3**);

the method of operation (see **2.2.1**).

3.1.1 Recording instruments are classified into one of the following accuracy classes related to the measured quantity:

0.2, 0.5, 1, 1.5, 2.5, 5.

3.1.2 Recording instruments are classified into one of the following accuracy classes related to time-keeping:

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

3.2 Accessories specified in this standard are classified as shown in **3.2.1** or **3.2.2**.

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

0.05, 0.1, 0.2, 0.5, 1.

3.2.2 Non-interchangeable accessories may also satisfy the requirements of this standard but have no accuracy class of their own (see **2.1.2.3**).

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

4.1 Permissible intrinsic errors. When the instrument, associated with its non-interchangeable accessories, 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.

NOTE Intrinsic error is determined excluding friction of the marking device on the chart.

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

Measuring class index	0.2	0.5	1	1.5	2.5	5
Limit of error	± 0.2 %	± 0.5 %	± 1.0 %	± 1.5 %	± 2.5 %	± 5.0 %

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 recorder shall be at the ambient temperature. This temperature shall be the reference temperature (see Table 3) within the stated tolerances. The internal relative humidity shall be that of the ambient.

The recorder shall be operated in accordance with the manufacturer's instructions and the auxiliary circuits, if any, shall be energized.

4.2.2 The recorder 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 recording instrument, all the measuring circuits shall be left in circuit under the conditions and for the time specified in Table 2.

4.2.3 After the preconditioning specified in Table 2, the recording device shall, where means are provided, be set on the appropriate chart line, the chart being advanced a distance of approximately 5 mm, by hand if necessary. For dotted line recorders it shall be considered to be set when two consecutive dots have been printed on the appropriate line.

For wattmeters and varmeters, the recording device shall be set on the appropriate chart line with the rated voltage applied to the voltage circuit(s), the current circuit(s) being interrupted in such a way that the potential between the voltage and current coils is the same as in normal operation.

Table 2 — Preconditioning of instruments

Test conditions	Instruments of measuring classes		
	0.2 ... 0.5	1 ... 5	
		Voltmeters	All other instruments
Voltage (as a percentage of rated voltage)	100	80	100
Current (as a percentage of rated current)	100	—	$66^{2}/_{3}$
Frequency	Reference	Reference	
Minimum time between connection into circuit and determination of errors	Any time (for convenience limited to 2 h)	$^{1}/_{2}$ h	

4.2.4 Multiple instruments which comprise a voltmeter and a wattmeter and/or varmeter shall be preconditioned using the voltage required for the wattmeter or varmeter.

4.2.5 Multirange instruments shall be energized on their highest range.

The next lower range shall next be tested after the instrument has been disconnected for 15 min, and then re-energized for 15 min at the values of voltage and/or current shown in Table 2 as applying to that range.

The same procedure shall be adopted for the other ranges.

4.2.6 Immediately before the determination of the intrinsic errors, the actual chart scale length shall be determined and its extremities marked on the chart.

The recorded value of the measured quantity is read either using the reference reading rule, if one is supplied, or using the chart scale lines.

When using the reference reading rule, the zero mark, or the mark assigned by the manufacturer, shall coincide with the appropriate chart line. When using the chart scale lines, a correction may be made by multiplying the value of the measured quantity by the ratio of the actual to the rated chart scale length.

4.2.7 The intrinsic errors are determined for increasing and decreasing values of the measured quantity according to the methods given in **4.2.7.1** and **4.2.7.2**.

4.2.7.1 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.

In order to minimize friction effect, the chart shall be driven for a sufficient time to allow the recording device to record a constant value of the measured quantity.

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

The second dot is taken as the recorded value, the first being ignored. During this time, the chart shall be running at such a speed that the two dots are easily distinguishable. If necessary, the chart may be moved forward by hand.

4.2.8 *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.

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

Influence quantity[a]	Reference conditions unless otherwise stated	Tolerance permitted for testing purposes applicable to a single reference value[b]
Ambient temperature	20 °C	Instruments of classes 0.2 ... 0.5: ± 1 °C Instruments of classes 1 ... 5: ± 2 °C
Relative humidity	50 %	40 % to 60 %
Position of supporting plane	Horizontal for portable Vertical for panel mounting	Instruments of classes 0.2 ... 0.5: 0.1° (unless fitted with a suitable level indicator). Instruments of classes 1 ... 5: 2°
External magnetic induction	Total absence of external induction	Value of induction of terrestrial magnetic field
Ferromagnetic panel	See Table 10	—
Conductive panel	Any panel	—
Frequency	50 Hz	± 2 % or ± $^1/_{10}$ of nominal range of use (whichever is smaller)[c]
Waveform of a.c. measured quantity	Sinusoidal	Distortion factor. For rectifier instruments, varmeters, phasemeters, power factor recorders: 1 % For all other instruments: 5 %
External electric field	Total absence	1 kV/m
Ripple content of d.c. supply	Zero	Instruments of classes 0.2 ... 0.5: 1 % 1 ... 5: 3 %
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] Although the chart speed has an influence on the friction effect, the error due to the latter is eliminated in the determination of the intrinsic error. The chart speed therefore is not considered to be an influence quantity.
[b] For a reference range, no tolerance is necessary.
[c] Examples for reference conditions and tolerance (see Table 3, frequency):
a) Nominal range of use: 15 ... 50 ... 100 Hz;
permitted tolerance on reference value: 2 % of 50 Hz = 1 Hz;
permitted tolerance for reference value as derived from nominal range of use: $^1/_{10}$ of 85 Hz = 8.5 Hz;
therefore: permitted tolerance = 1 Hz.
b) Nominal range of use: 49 ... 50 ... 51 Hz;
permitted tolerance on reference value: 2 % of 50 Hz = 1 Hz;
permitted tolerance for reference value as derived from nominal range of use: $^1/_{10}$ of 2 Hz = 0.2 Hz;
therefore: permitted tolerance = 0.2 Hz.

Table 4 — Reference conditions for voltage, current and power factor related to the measured quantity

Recording instruments	Reference conditions		
	Voltage	Current	Power factor
Wattmeters	Rated voltage ± 2 %	Any current up to the rated current or up to the upper limit of the reference range, if any	cos φ = 1 (tolerance 0.01) or rated cos φ ± 0.01
Varmeters	Rated voltage ± 2 %	Any current up to the rated current or up to the upper limit of the reference range, if any	sin φ = 1 (tolerance 0.01) or rated sin φ ± 0.01
Phasemeters and power-factor meters	Rated voltage ± 2 %	Any current within the reference range. If not otherwise marked, the reference range is 40 % to 100 % of rated current	
Frequency meters	Rated voltage ± 2 % or any voltage within the reference range		
Polyphase instruments	Symmetrical voltages[a]	Symmetrical currents[a]	
Other elements of multiple measuring element instruments[b]	a) Voltage measuring elements: 80 % of rated voltage. Other elements: rated voltage	Current measuring elements: 80 % of rated current. Other elements: 80 % of rated current	cos φ = 1 or rated cos φ (nominal only)
	b) Same conditions as for the measuring element under test		

[a] Each of the voltages (between any two lines, or between any line and neutral) of a polyphase symmetrical system shall not differ by more than 1 % from the average of the voltages (line-to-line or line-to-neutral) of the system.
Each of the currents in the phases shall not differ by more than 1 % from the average of the currents.
The angles between each of the currents and the corresponding phase-to-neutral voltages shall not differ by more than 2°.
[b] Reference conditions a) or b) apply as follows:
a) instruments with separate terminals for each element if single phase or with a connection diagram giving the phase relationship of the elements if polyphase.
b) instruments with internal connections and a common set of terminals.

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.

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 %

5.2 Conditions under which intrinsic errors of instruments shall be determined

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

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.

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		Horizontal for portable Vertical for panel mounting	± 2°
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 manufacturers' instructions

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

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 values.

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 as a percentage of the fiducial value

Class index	0.05	0.1	0.2	0.5	1
Limit of error	± 0.05 %	± 0.1 %	± 0.2 %	± 0.5 %	± 1.0 %

6.2 Accessories of limited interchangeability

6.2.1 The intrinsic error of these accessories shall be within the limit of error as stated in Table 7 and shall be expressed as a percentage of the fiducial value.

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 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 circuit 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** or **11.4**.

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 the 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 **7.1.3** to **7.1.7** 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 and **7.1.3** to **7.1.7** shall be made at the following points for all instruments except for those listed in **7.1.2.3**.

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.

c) At zero indication, for certain influence quantities such as position and power factor and, for recorders of measuring classes 0.2 ... 0.5, at ambient temperature.

7.1.2.3 Exceptions to **7.1.2.2**:

a) for recorders with the zero within the effective range, tests shall be carried out at one point on each side of zero;

b) for recording phasemeters and power-factor recorders, tests shall be carried out at two points within the effective range agreed between the manufacturer and the user.

7.1.2.4 When determining the variation due to the mounting position and also, for instruments of measuring accuracy classes 0.2 ... 0.5, due to ambient temperature according to **7.1.2.2** a) and b), the recording device shall be reset to zero before making the record after the influence quantity has been varied.

7.1.2.5 A variation is determined by means of two successive measurements for the two values of the influence quantity given in **7.1.2.6**, 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 recorded quantity. For each measurement, the record is made in accordance with **4.2.7.1** so that the friction effect is negligible.

For wattmeters and varmeters, the value of power shall be increased and decreased by varying the value of the current, the voltage and power factor remaining unaltered.

7.1.2.6 The degree of variation is assessed as specified in **7.1.2.6.1** and **7.1.2.6.2**.

7.1.2.6.1 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.

7.1.2.6.2 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.

7.1.2.7 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 with its measuring element in the centre of a coil of 1 m mean diameter, of small cross-sectional area, and of 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 dimension 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 mean 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 17, 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 variation 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 17, 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 the limits given in Table 9.

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

Influence quantity[a]	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		100 %
Position of supporting plane	Reference position ± 5° NOTE Instruments equipped with levelling means are excluded from these requirements		50 %
Frequency 1) single-phase power-factor recorders, varmeters and those wattmeters which employ phase-shifting devices	Reference frequency ± 1 %		100 %
2) all other recording instruments	Reference frequency ± 10 %		100 %
Voltage	Reference voltage ± 15 %		100 %
Current (for power-factor recorders)	20 % and 120 % of rated current		100 %
	Instruments of classes 0.2 ... 0.5	Instruments of classes 1 ... 5	
Power-factor (cos φ) for wattmeters	Rated cos φ and cos φ = 0	Rated cos φ and $^1/_2$ rated cos φ lagging	100 %
sin φ for varmeters	Rated sin φ and sin φ = 0	Rated sin φ and $^1/_2$ rated sin φ lagging	100 %

[a] Although the chart speed has an influence on the friction effect, the latter is eliminated in the determination of the intrinsic error; therefore the chart speed is not considered to be an influence quantity and has no nominal range of use.

Table 9 — Permissible limits of variation for a magnetic induction of 0.5 mT

Instruments	Measuring class index	
	0.2 ... 0.5	1 ... 5
Permanent-magnet moving-coil	± 0.75 %	± 1.5 %
Ferrodynamic	± 1.5 %	± 3.0 %
Others	± 3.0 %	± 6.0 %

7.1.3.4 The induction shall be provided by a current of the same kind and frequency as the input circuit supply. When the measuring element 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 kHz. 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 10), 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 symbols Fe, NFe or Fe.NFe (see Table 10) 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 in accordance with Table 10, 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 10 are exempt from the test of **7.1.4.3**.

Table 10 — 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**

7.1.5 *Variation due to mounting on supports of conductive material.* Unless otherwise shown by marking with the symbol F-33 of Table 17, instruments shall meet the requirements of clause **4** when mounted on a support of high conductivity.

7.1.6 *Variation due to unbalanced currents in polyphase wattmeters and varmeters.* The variation due to unbalanced currents shall not exceed 200 % of a value corresponding to the measuring class index. The variation shall be determined in the following manner.

The instrument shall be maintained under the conditions stated in Table 2, Table 3 and Table 4.

The currents are adjusted to be equal so that the recording device is approximately in the middle of the effective range. The record is noted.

One current circuit is disconnected, the voltages being maintained balanced and the other currents are maintained equal and are adjusted so as to give the initial value of the record. The change in the measured quantity determined on the standard instrument is considered to be the variation.

7.1.7 ***Variation due to the recording device of continuous line recording instruments***

7.1.7.1 *Quantity of ink.* The variation which arises as a result of a change of the quantity of ink in the pen or in the ink well shall not exceed 50 % of a value corresponding to the measuring class index when the quantity of ink is changed within one of the limits of the reference range and the corresponding limit of the nominal range of use.

When no limits are stated, the limits of the nominal range of use for the quantity of ink are 10 % and 100 % of the maximum quantity.

7.1.7.2 *Stylus supply voltage.* When the supply voltage to the stylus is changed between its rated value and the limits of the nominal range of use, the resultant variation shall not exceed a value corresponding to 50 % of the measuring class index. When no limits are stated, the limits of the nominal range of use shall be 90 % and 110 % of the rated voltage.

7.1.8 ***Variation due to continuous operation***

7.1.8.1 All instruments, together with their accessories, shall comply with the requirements appropriate to their accuracy class when they are continuously loaded at their rated current and/or voltage under the reference conditions in Table 3, Table 4 and Table 6.

7.1.8.2 The effect of self-heating on instruments and accessories shall be determined as follows:

Instruments and accessories, if any, shall be at ambient temperature and shall have been disconnected for not less than 4 h. They shall then be energized and the error in the record, at approximately 80 % of the upper limit of the effective range, shall be determined before the elapse of 3 min and after 30 min, operation being continuous at about the same recorded value between determinations. The difference between the errors shall not exceed 100 % of the class index.

For multirange or multipurpose instruments, this test shall be conducted on the range, and with the measured quantity incurring the greatest power loss within the instrument and accessory, if any.

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 shall not exceed 100 % of a value corresponding to the time-keeping class index.

7.2.1.1 Where other influence quantities not listed in Table 11 are applicable, the normal values of the limits of the nominal range of use shall be stated.

7.2.2 *Conditions under which the variations shall be determined.* The variations shall be determined for each influence quantity shown in Table 11. 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.

Table 11 — 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°	All mechanisms

8 Permissible limits of variations for interchangeable accessories

8.1 The variations 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 50 % of a value corresponding to 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 Relationship between the type of recording instrument and accuracy class. The relationship between the type of recording instrument and the accuracy class shall be as specified in Table 12 unless otherwise agreed between the manufacturer and the user.

Table 12 — Relationship between the type of recording instrument, the type of chart driving mechanism and the accuracy class

Type of recording instrument		Measuring class index
Continuous recording instruments and dotted line recording instruments	a.c. or d.c. voltmeter	1, 1.5 or 2.5
	d.c. millivoltmeter	1, 1.5 or 2.5
	a.c. or d.c. ammeter	1, 1.5 or 2.5
	a.c. or d.c. wattmeter or varmeter recording	2.5 or 5
	phasemeter or power factor recorder frequency	2.5 or 5[a]
	recorder where the effective range is:	
	up to 10 % of the mean frequency	0.2
	above 10 % and up to 20 % of the mean frequency	0.5 or 1
	above 20 % of the mean frequency	1
		Time-keeping class index
Chart-driving mechanism	Synchronous motor	0.02 ... 0.2
	Spring-driven clockwork with escapement	0.1 ... 0.2
	Spring-driven clockwork with fly governor	5

[a] For the sake of uniformity, the error is given in terms of the measuring class index. Measuring class indices 2.5 and 5 imply a limit of error of ± 2.5° and ± 5.0° of phase angle respectively.

9.2 Determination of the maximum value of friction effect on continuous line recording instruments (see Appendix B)

9.2.1 The maximum value of friction effect (ε_f) is determined under the conditions specified in **9.2.1.1** and **9.2.1.2**.

9.2.1.1 Tests shall be taken at each of three values on the chart scale, chosen between 5 % to 15 %, 45 % to 55 % and 85 % to 95 % of the chart scale length.

9.2.1.2 The chart being stationary, the measured quantity is applied to the instrument under test and to a reference instrument.

All changes in the measured quantity are made in such a way as to avoid any overshoot.

The test is carried out as follows.

1 The measured quantity is increased until the chosen value is shown on the reference instrument.
2 The measured quantity is reduced by an amount corresponding to about 5 % of the chart scale length.
3 The chart is advanced about 2 mm by hand.
4 The measured quantity is increased until the chosen value is exceeded by an amount corresponding to about 5 % of the chart scale length.
5 The chart is advanced about 2 mm by hand.
6 The measured quantity is reduced until the chosen value is shown on the reference instrument.
7 The measured quantity is increased until the chosen value is exceeded by an amount corresponding to about 5 % of the chart scale length.
8 The chart is moved forward about 2 mm by hand.
9 The measured quantity is reduced to a value less than the chosen value by an amount corresponding to about 5 % of the chart scale length.
10 The chart is moved forward about 2 mm by hand.
11 Steps 1 to 10 are then repeated twice more.
12 Steps 1 to 11 are carried out for each of the three values given in **9.2.1.1**.

9.2.1.3 The record so obtained gives, for each of the three values, three groups of two reversal points, the distance between which is noted. For each value, the greater distance is disregarded.

9.2.1.4 The maximum value of friction effect (ε_f) is taken to be equal to half the greatest of the six remaining values. It is expressed as a percentage of the chart scale length.

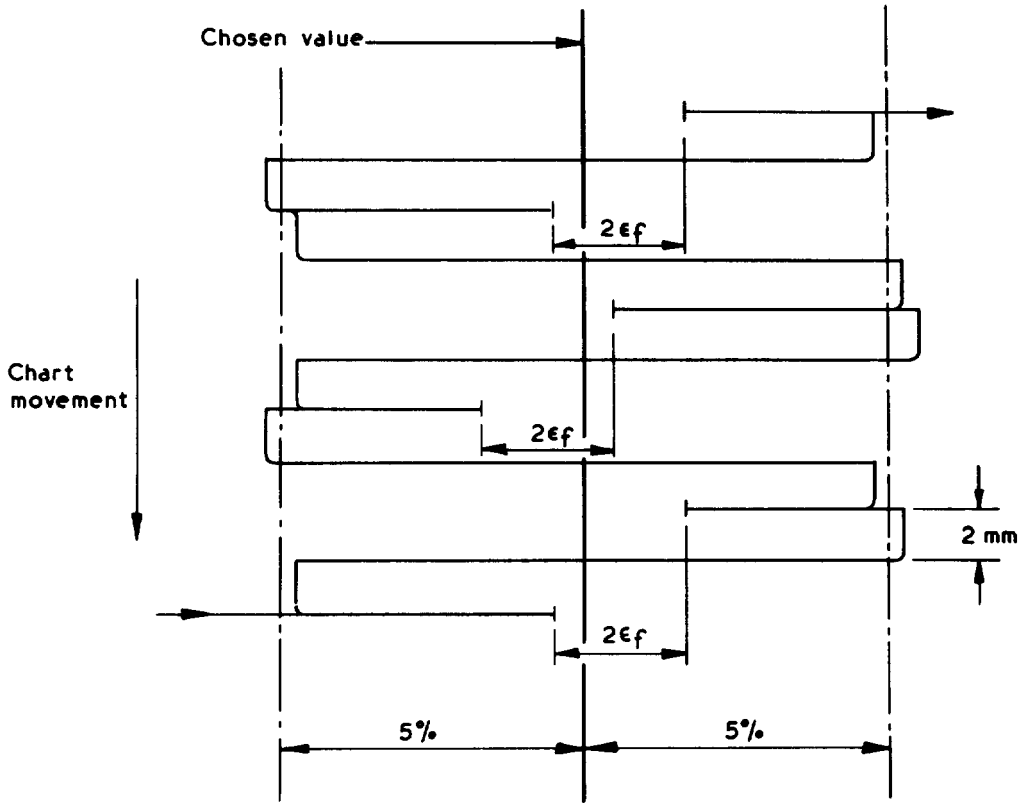


Figure 1 — Determination of maximum value of friction effect

9.2.2 The maximum value of friction effect determined according to **9.2.1** shall not exceed the limit which is specified by the manufacturer and marked on the instrument (symbol K-1 of Table 17).

If this limit is represented by the same number as the measuring class index, it need not be marked on the instrument.

If this limit is represented by a number which differs from the measuring class index, the number should be chosen from the values shown in Table 1.

For suppressed-zero recording instruments, the limit shall be marked.

NOTE For suppressed-zero recording instruments, the number representing the limit of the friction effect may appear high in comparison with the measuring class index due to their different methods of determination. To obtain a truer picture of the possible error introduced by friction, the number representing the limit of friction effect should be divided by the suppression ratio.

9.3 Damping. The damping of a recording instrument shall comply with the following requirements.

9.3.1 *Overshoot.* The recording instrument, being unenergized and with the chart stationary, is suddenly connected to a circuit where the measured quantity is such that it would produce a steady deflection of $^2/_3$ of the total scale length. When the zero of the recording instrument is displaced within the scale, the scale length shall be taken as being the longer of the scale lengths on either side of the zero.

For recording instruments with the mechanical zero not on the scale (e.g. suppressed zero) or without determinate mechanical zero (e.g. phasemeters) the instrument is energized by connecting it to a source so that a deflection corresponding to the lower limit of the effective range is produced. The recording instrument is then suddenly switched over to a connection with a source that will produce a steady deflection of $^2/_3$ of the effective range. (This may be done by a sudden readjustment of the same source.) The maximum deflection shall not exceed the final steady deflection by a quantity corresponding to 7 % of the chart scale length.

This requirement does not apply to dotted line recording instruments.

9.3.2 *Damping time.* When the instrument is under the conditions specified in **9.3.1**, the instrument shall comply with the requirements of **9.3.2.1** and **9.3.2.2**.

9.3.2.1 For continuous line recording instruments, the departure of the recording device from the position of rest shall not exceed a percentage of the total chart scale length corresponding to 100 % of the measuring class index at any time after 4 s when subjected to the test conditions of **9.3.1**.

For the purposes of this test, it has been assumed that the number representing the limit of friction effect will not be greater than the measuring class index. If this is not so, then the symbol F-33 shall be used.

9.3.2.2 For dotted line recording instruments, the damping time shall be less than the time interval between the recording of two immediately successive dots.

9.3.3 When the characteristics of the circuit into which the recorder is connected may affect the damping, the external circuit impedance shall be stated by the manufacturer.

In the absence of such a statement, the external circuit impedance for milliammeters and ammeters is assumed to be more than 50 times that of the instrument and for millivoltmeters and voltmeters less than $^1/_{50}$ that of the instrument.

9.3.4 The requirements of **9.3.1** and **9.3.2** do not apply to the following types of recording instruments:

instruments specially designed with a long damping time and bearing symbol F-33 of Table 17.
electrically operated recording measuring instruments.

9.4 Inking

9.4.1 *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)

The thickening of the record resulting from parastic vibration of the recording device due to the application of an alternating measured quantity shall not exceed 50 % of a value (in millimetres) corresponding to the measuring class index. Tests to determine the thickening of the record shall be made at any frequency within the nominal range of use and with a substantially constant value of the measured quantity.

9.4.2 *Recording at the upper limit of the frequency response for continuous line recording instruments only.* The test shall be made with the zero of a sinusoidally varying measured quantity approximately at the midpoint of the effective range.

The chosen measured quantity shall have a peak-to-peak amplitude of approximately two-thirds of the effective range. The chart shall be moving at the highest rated chart speed and the recording device shall record at least one complete cycle as a continuous line.

During this test, the recorded values (peak-to-peak) shall not differ from the chosen value by more than 10 %.

9.4.3 *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.

9.5 Permissible overloads. After completion of the tests described in **9.5.1**, **9.5.2**, **9.5.3** and **9.5.4** and after cooling to the reference temperature, instruments and accessories shall comply with the requirements appropriate to their measuring and time-keeping class indices (see clauses **4**, **5**, **6** and **7**) other than those relating to overloads.

9.5.1 *Continuous overload for recording instruments of measuring classes* 1 ... 5. All measuring circuits shall simultaneously be subjected to an overload of 120 % of:

the rated value(s); or

the upper limit of the reference range(s); or

the nominal range(s) of use, whichever is the greatest; or

of the value(s) assigned by the manufacturer.

Whichever value is chosen, it shall be applied for a period of 2 h, each influence quantity being maintained at its reference value. Where relevant, the power factor shall be the rated value.

After cooling to its reference temperature, the instrument shall comply with the requirements appropriate to its measuring and time-keeping class indices.

9.5.2 *Overloads of short duration (mechanical withstand).* The tests shall be made under reference conditions.

The overload tests of short duration which the instruments shall withstand are given in Table 13. For any type of instrument, all the overload tests of short duration shall be carried out in the order given in Table 13, the test circuit being practically nonreactive. When damping is affected by the external circuit, the test circuit shall conform to the values specified by the manufacturer.

9.5.2.1 The current and voltage for these tests is the product of the factor given in Table 13 and

the rated value, or

the upper limit of the reference range, or the upper limit of the nominal range of use, if any, whichever is the greater,

or

the value assigned by the manufacturer.

9.5.2.2 An instrument with a marked zero is considered to be undamaged when, after the test, and after the instrument has cooled to its reference temperature, the zero variation expressed as a percentage of the chart scale length is less than 100 % of a value corresponding to the measuring class index.

The instrument, after readjustment of the zero, and resetting and refilling the recording device, if necessary, shall meet the requirements of clause **4**.

9.5.2.3 An instrument without mechanical zero is considered to be undamaged if it satisfies the requirements of clause **4** after the instrument has cooled to the reference temperature and after resetting and refilling the recording device, if necessary.

9.5.2.4 The following instruments are excluded from the requirements of **9.5.2**:

bimetallic instruments,

rectifier instruments,

thermocouple instruments,

electrically operated measuring instruments.

Table 13 — Overload test of short duration

Recording instruments	Current factor	Voltage factor	Number of overloads	Duration of each overload s	Interval between two overloads s
Measuring classes 0.2 ... 0.5 *and rectifier instruments of all measuring classes*					
Ammeters	2	—	5	[a]	15
Voltmeters and frequency recorders	—	2	5	[a]	15
Wattmeters, varmeters and recording phasemeters	1 2	2 1	1 5	5 [a]	— 15
Measuring classes 1 ... 5					
Ammeters	5 5	— —	9 1	0.5 5	60
Voltmeters and frequency recorders	— —	2 2	9 1	0.5 5	60 —
Wattmeters, varmeters and recording phasemeters	5 5 1	1 1 2	9 1 1	0.5 5 5	60 — —

[a] The overload shall be removed immediately the recording device reaches the upper limit of its travel.

9.5.3 *Overloads of short duration for shunts.* Shunts shall be capable of withstanding for 5 s, the overloads given in Table 14 under ventilating conditions to be specified by the manufacturer for normal use.

Table 14 — Current factor for overloads of short duration for shunts

Shunt of classes	Rated current	Current factor
0.05 ... 0.2	Any	2
0.5 ... 1	Up to and including 500 A above 500 A, up to and including 2 000 A above 2 000 A, up to and including 10 000 A	10 5 2
Any	Above 10 000 A	By agreement between manufacturer and user

9.5.4 *Overloads of short duration for series resistors and impedances.* Five overloads each lasting one second shall be applied in succession at intervals of 15 s, at a voltage equal to twice the rated voltage.

9.6 Temperature limits

9.6.1 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 dotted line recording instruments.

9.6.2 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.

9.7 Mutual influence

9.7.1 *Influence of interaction between the measuring elements of polyphase electrodynamic wattmeters and varmeters.* The effect of interaction between the measuring elements of polyphase electrodynamic wattmeters and varmeters shall be determined under reference conditions as specified in **9.7.1.1**, **9.7.1.2** and **9.7.1.3**.

9.7.1.1 The voltage circuit of one measuring element shall be energized at rated voltage and rated frequency. The current circuit of each of the other measuring elements shall be energized in turn at rated current. The maximum departure of the recording device from the zero chart scale mark shall be noted as the phase angle between the voltage and current is changed through 360°.

9.7.1.2 The test shall be repeated with the voltage circuit of each of the other measuring element(s) being individually energized in turn.

9.7.1.3 The maximum value of the departure of the recording device from the zero chart scale mark shall not exceed 50 % of a value corresponding to the measuring class index in terms of the total chart scale length.

9.7.2 *Determination of the mutual influence between the different measuring elements of a multiple instrument.* The variation is determined by energizing one measuring element so that a deflection of 80 % of the upper limit of the effective range is obtained; the measured quantity applied to each of the other measuring elements is then varied from the maximum to the minimum value of their effective ranges in the most unfavourable phase conditions. The maximum variation in the record of the first measuring element is noted. The test is repeated, in turn, on every other measuring element.

Any variation shall not exceed 50 % of a value corresponding to the measuring class index in terms of the total chart scale length.

This requirement does not apply to instruments with measuring elements connected to a common set of terminals.

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 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 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 (Table 17).

The values of the test voltages corresponding to the nominal circuit voltages (circuit insulation voltages) of the circuit(s) under test are shown in Table 15.

When the nominal circuit voltage (circuit insulation voltage) of an ammeter is not shown, the ammeter shall be tested at 2.0 kV.

Table 15 — 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 11.2 (7)**
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, e.g. with single-phase wattmeters, varmeters and power-factor recorders when intended to be connected to one phase only, or with polyphase wattmeters the circuits of which are connected to the same phase.

The test voltage is limited to 50 V for wattmeters and varmeters with voltage circuit compensation and the symbol F-33 of Table 17 shall be shown in these circumstances, or

b) Chosen according to Table 15 when the circuits are intended to be, or are likely to be, connected to different voltages or phases, e.g. with polyphase wattmeters, varmeters and power-factor recorders intended for use on different phases or with several measuring elements in a common enclosure, or

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

9.8.2.4 *Voltage test on auxiliary circuits.* A further voltage test shall be made when auxiliary circuits are incorporated in the instrument. 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 15, but the symbol (see Table 17) for this test voltage is not marked. Auxiliary circuits having a nominal circuit voltage (circuit insulation voltage) of 50 V or less and inactive conducting parts of the instrument 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) for 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.* 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 recording instruments and their 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 Chart scales

10.1.1 *Divisions.* 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.

10.1.2 *Limits of the effective range.* When the effective range does not correspond to 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 chart scale lines enables the effective range to be identified without ambiguity.
(See Appendix A.)

10.2 Preferred values

10.2.1 *Upper limits of the effective range of ammeters, voltmeters, wattmeters and varmeters.* The upper limit of the effective range of ammeters, voltmeters, wattmeters and varmeters 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.

10.2.2 *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.

10.2.3 ***Values of chart speed***

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

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

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

1 revolution in 1 day or 7 days.

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

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

10.3 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 17.

11 Markings and symbols for instruments and their 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 internationally agreed practice.

11.2 Markings and symbols. For most of these markings the symbols given in Table 17 are used.
See also BS 1991-6.

The following items of 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 (or indices)

6 Nature of the measured quantity and number of measuring elements
7 Test voltage
8 Symbol indicating the operating method of the measuring element(s)
9 Nature of chart-driving mechanism
10 Chart speed(s)
11 Rated values of the auxiliary power supply
12 Rated running time
13 Limit of the maximum value of friction effect
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 Symbol F-31 (Table 17), marked near the protective earth terminal on an instrument having such a 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(s) of any non-interchangeable 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 corresponds to a value corresponding to the measuring class index, if relevant
23 Symbols showing the panel for which the instrument has been calibrated, if relevant
24 Value of the source impedance 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 chart scale does not coincide with the measured quantity (e.g.: mV for maximum scale deflection).

11.2.1 Markings and symbols for the following items of information, as enumerated in **11.2**, shall appear on the instrument and in a separate document (if any):

items 1, 2, 3, 4, 5.

The serial number (item 3) is required in the associated document only if it is necessary to relate that document to a particular instrument.

11.2.2 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, 14, 15, 16, 17, 18, 19, 20, 26.

11.2.3 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, 13, 21, 22, 23, 24, 25.

11.3 Markings and symbols for shunts. Shunts shall bear markings and symbols giving the information 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 0.05 ... 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 0.05 ... 0.1
3 Class index
4 Designation of the type 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 The reference to the diagram of connections, if necessary.

11.4 Markings and symbols for series resistors and impedances. Series resistors and impedances shall bear markings and symbols giving the information 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 0.05 ... 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 *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 0.05 ... 0.1
3 Class index
4 Designation of the type of the associated instrument
5 Rated voltage(s) of the accessory and the instrument combined
6 Reference value, or the reference range of frequency, when it differs from 45 Hz to 65 Hz
7 Test voltage, when in a separate enclosure
8 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 and Table 4. These markings shall be made on the instrument or accessory or in a document supplied with them, using the unit symbol given in Table 17 or in BS 1991.

11.5.2 The nominal range of use shall be marked if different from that given in Table 8 and Table 11.

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 16) show the significance of the various markings for temperature or frequency.

Table 16 — Examples of markings 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 3) Nominal range of use: 10 °C to 30 °C (see Table 8) Similarly for other influence quantities
One number	25 °C	Reference value: 25 °C Nominal range of use: 15 °C to 35 °C (see Table 8)
Three numbers	20 ... 25 ... 30 °C	Reference value: 25 °C Nominal range of use: 20 °C to 30 °C (Nominal range of use different from that specified in Table 8)
Three numbers	15 ... 45 ... 65 Hz	Reference range: 45 Hz to 65 Hz 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 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 Nominal range of use: 15 Hz to 65 Hz (permissible variations from 55 Hz to 65 Hz)

12 Categories of test

12.1 All recording 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 17 — Symbols for marking instruments and accessories
(If other units and prefixes are needed, see BS 1991).

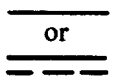
No.	Item	Symbol
A Principal units and their principal multiples and sub-multiples		
A–1	kiloampere	kA
A–2	ampere	A
A–3	milliampere	mA
A–4	microampere	μA
A–5	kilovolt	kV
A–6	volt	V
A–7	millivolt	mV
A–8	microvolt	μV
A–9	megawatt	MW
A–10	kilowatt	kW
A–11	watt	W
A–12	megavar	MVAr
A–13	kilovar	kVAr
A–14	var	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 Celsius	°C
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	

Table 17 — Symbols for marking instruments and accessories
(If other units and prefixes are needed, see BS 1991).

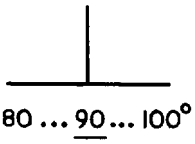
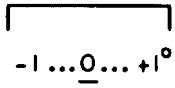
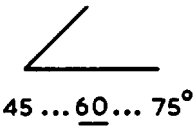
No.	Item	Symbol
B–7	One measuring element for 4-wire network	
B–8	Two measuring elements for 3-wire network with unbalanced loads	
B–9	Two measuring elements for 4-wire network with unbalanced loads	
B–10	Three measuring elements for 4-wire network with unbalanced loads	
C Safety		
C–1	500 V	
C–2	Above 500 V, expressed in kilovolts (e.g. 2 kV)	
C–3	Apparatus not subjected to a voltage test	
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 in D–1; nominal range of use 80°... 100°	
D–5	Example for instrument to be used as in D–2; nominal range of use – 1°... + 1°	
D–6	Example for instrument to be used as in D–3; nominal range of use 45°... 75°	

Table 17 — Symbols for marking instruments and accessories
(If other units and prefixes are needed, see BS 1991).

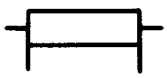
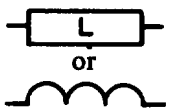
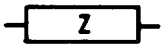
No.	Item	Symbol
E Accuracy classes		
E–1	Class index (e.g. 1.5) with errors expressed as a percentage of the fiducial value	1.5
E–2	Not allocated	
E–3	Not allocated	
E–4	Not allocated	
F General symbols		
F–1	Not allocated	
F–2	Not allocated	
F–3	Not allocated	
F–4	Not allocated	
F–5	Not allocated	
F–6	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	
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	

Table 17 — Symbols for marking instruments and accessories
(If other units and prefixes are needed, see BS 1991).

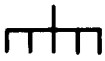
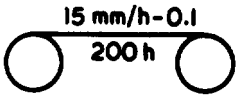
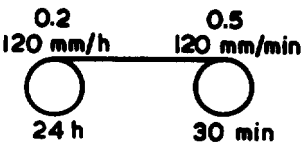
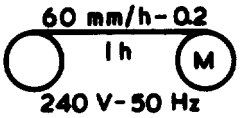
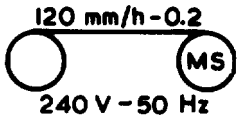
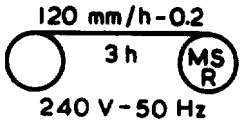
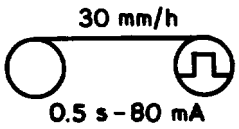
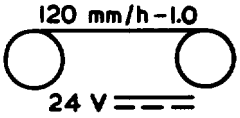
No.	Item	Symbol
F–28	Not allocated	
F–29	Not allocated	
F–30	Magnetic induction, expressed in millitesla, resulting in a variation having a value corresponding to 100 % of the measuring class index (e.g. 0.5 mT)	
F–31	Protective earth terminal	
F–31A	Measuring earth terminal	
F–32	Zero adjuster	
F–33	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*)
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 Rated chart speed: 15 mm/h Rated running time: 200 h Time-keeping accuracy class: 0.1	
H–2	Spring-driven, hand-wound clockwork with two rated chart speeds Rated chart speeds: 120 mm/h and 120 mm/min Rated running time: 24 h and 30 min respectively Time-keeping accuracy class: 0.2 at 120 mm/h 0.5 at 120 mm/min	[a] 
H–3	Spring-driven, electrically wound clockwork Rated chart speed: 60 mm/h Supply: 240 V – 50 Hz Rated running time: 1 h Time-keeping accuracy class: 0.2	[a] 
[a] These symbols differ in detail from those internationally agreed.		

Table 17 — Symbols for marking instruments and accessories
(If other units and prefixes are needed, see BS 1991).

No.	Item	Symbol
H–4	Synchronous motor Rated chart speed: 120 mm/h Supply: 240 V – 50 Hz Time-keeping accuracy class: 0.2	
H–5	Synchronous motor with running reserve Rated chart speed: 120 mm/h Supply: 240 V – 50 Hz Running reserve: 3 h Time-keeping accuracy class: 0.2	[a] 
H–6	Impulse-driven motor Rated chart speed: 30 mm/h Current supply: 80 mA Impulsing rate: 0.5 s (i.e. 2 impulses/s)	
H–7	Other forms of chart-driving mechanism	
H–8	d.c. motor Rated chart speed: 120 mm/h Supply: 24 V d.c. Time-keeping accuracy class: 1.0	[b] 
K Symbol for friction effect		
K–1	Maximum value of the friction effect (e.g. 0.5) expressed as a percentage of chart scale length	

NOTE For other symbols, see BS 3939.
[a] These symbols differ in detail from those internationally agreed.
[b] This symbol has no international equivalent.

Appendix A Concepts

This standard includes certain concepts additional to those which were used in the previous editions. These new concepts (e.g. fiducial value), which have been defined in clause **2**, permit a better understanding of the qualities of the measuring apparatus.

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.

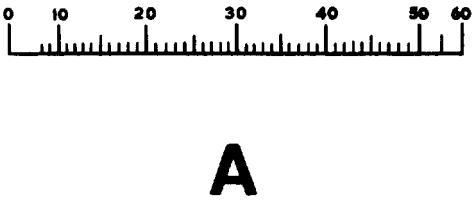


Figure 2 — Effective range 8A to 50 A (sub-division omitted outside effective range)

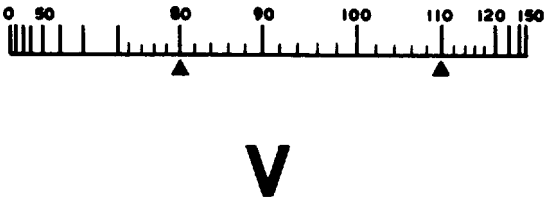


Figure 3 — Effective range 80 V to 110 V (effective range ▲ ... ▲)

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.

Unless otherwise stated, the effective range of an instrument should be from full scale value down to that proportion of the fiducial value shown in Table 18.

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 18 — Lower limit of effective range

Form of movement	Lower limit of effective range expressed as a fraction of the fiducial value
Permanent-magnet moving-coil	$^1/_{10}$
Electrodynamic and ferrodynamic wattmeter	$^1/_{10}$
Rectifier instruments, except voltmeters below range 0–15 V	$^1/_{10}$
Moving-iron	$^1/_5$
Rectifier voltmeters, below range 0–15 V	$^1/_4$
Electrodynamic and ferrodynamic ammeter and voltmeter	$^1/_3$
Thermocouple ammeters and voltmeters	$^1/_3$

Table 19 gives examples for the fiducial value for particular cases.

Table 19 — Examples of limits of effective range and fiducial values

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 17*

40 °C

In this example, this standard (see Table 3 and Table 8) 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). 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 17*

– 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.

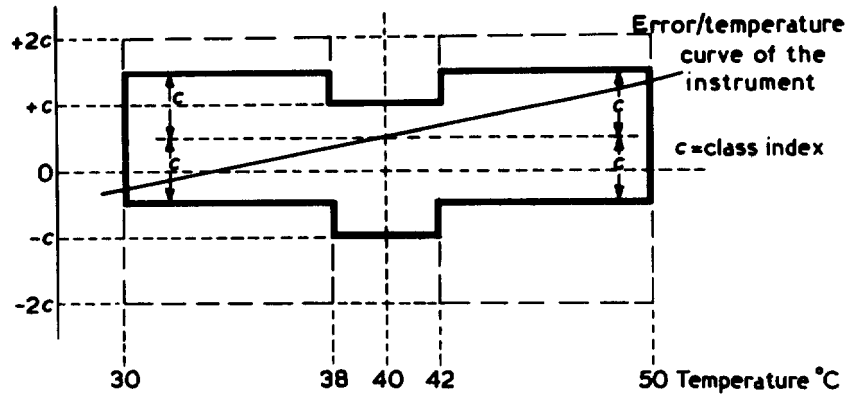


Figure 4 — Effect of temperature. Reference value 40 °C

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.

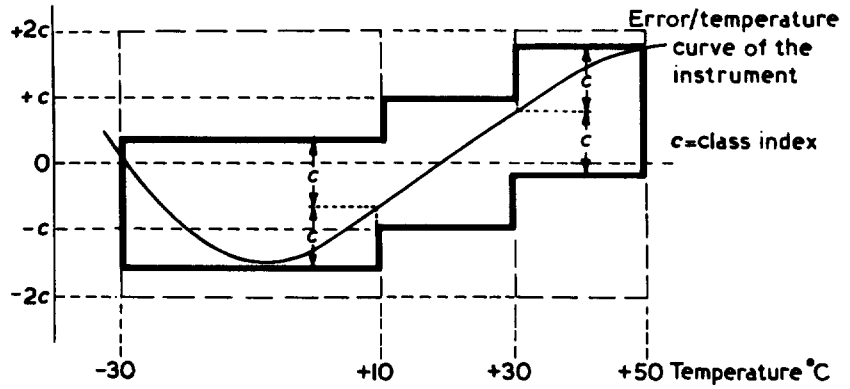


Figure 5 — Effect of temperature

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 17*

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.

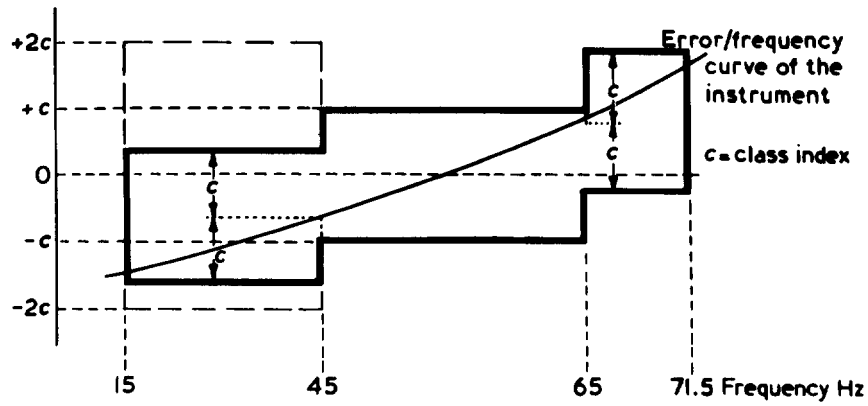


Figure 6 — Effect of frequency

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 tests

a) Limits of intrinsic errors (see clauses **4** and **5**)	routine test
b) Limits of variation due to position (see Table 8)	routine test
c) Limits of variation due to other influence quantities (see clauses **6** and **7** and Table 8)	type test
d) Damping (see **9.3**)	type test
e) Continuous operation (see **7.1.8**)	type test
f) Permissible overloads (see **9.5**)	type test
g) Temperature limits of operation (see **9.6**)	type test
h) Mutual influences (see **9.7**)	type test
i) Voltage tests (see **9.8.2**)	routine test
j) Insulation resistance test (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 difference 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.

Appendix B Friction effect of electrical measuring instruments of the direct acting continuous line recording type

Continuous line recording instruments may show, as a result of contact of the marking device with the chart surface, a friction effect (see **2.7.1.5**) the maximum value of which may not be negligible and may be comparable with the intrinsic error.

The friction effect, constituting a part of the total error in recording, differs in its nature from the moving element friction (bearings) because its influence decreases as a function of time when the chart is moving, while the friction of the moving element remains constant with time. It will be clear that the friction effect is not analogous to variation due to an influence quantity.

It might seem obvious to determine the intrinsic error by including in it the maximum friction effect, which will occur under the most unfavourable conditions. But this method would not be in accordance with the idea of intrinsic error mentioned above, as it is not intended that the intrinsic error shall include all influences which may occur in the most unfavourable conditions.

An analysis of friction effect shows that when the quantity to be measured is varied continuously and without overshoot, as far as a certain Y_t value, with the chart stationary, the latter being then set in motion, a trace is drawn having one of the forms shown in Figure 7.

If, on the other hand, the quantity to be measured is varied linearly while the chart is in motion, the recorded trace will be analogous to that of Figure 8, and comprises a straight section, followed by a curve similar to that of Figure 7.

It will be seen that the friction effect, the maximum value of which is represented by distance ϵ_f, decreases rapidly when the chart is in motion. The friction effect occurring in the recorded trace at a given moment is a fraction of the maximum effect, which may practically vary between the limits 0 % and 100 % of ϵ_f and which depends on a large number of factors including:

a) maximum value of friction effect ϵ_f;

b) chart speed;

c) rate of variation of the measured quantity;

d) time constant of measurement;

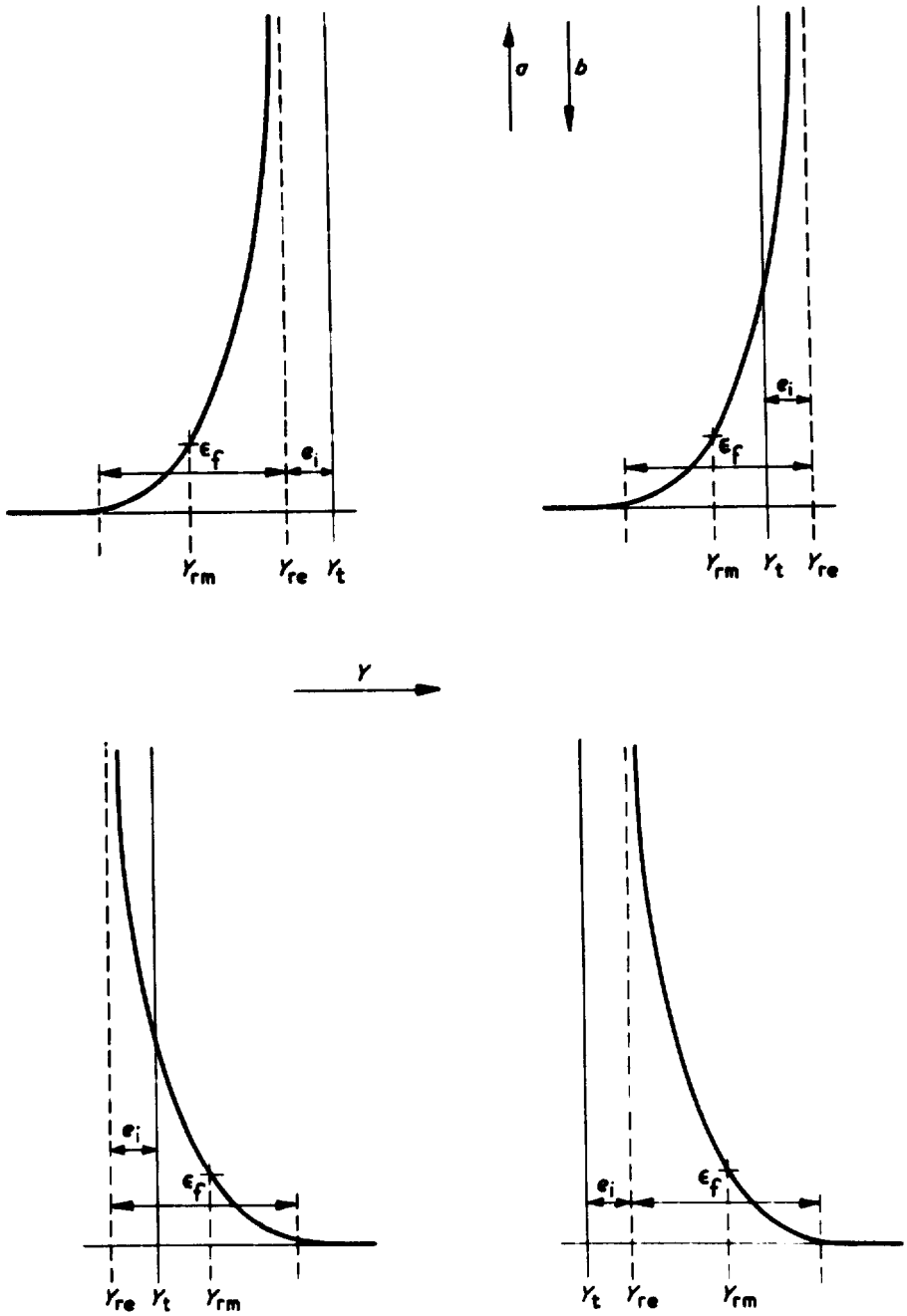
e) damping factor of the instrument;

f) influence of vibration, etc.

The friction effect, expressed as a percentage of chart scale length, must be smaller than a limit marked. If the limit can be expressed by the same figure as the class index, no separate marking is necessary.

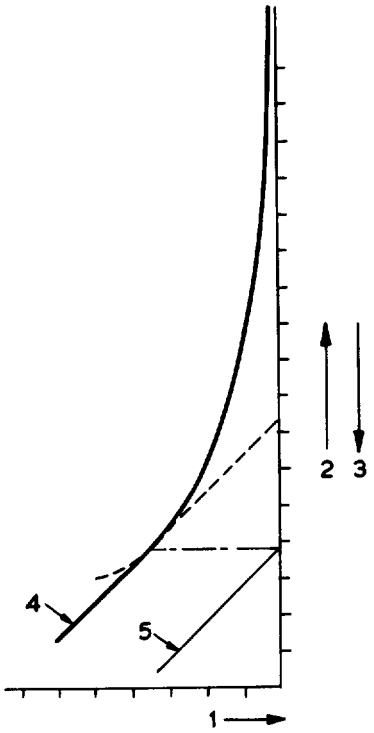
This concept is in accordance with the principle that standards for recording instruments should run parallel to those for indicating instruments as far as possible, and that divergences should occur only if justified by physical reasons. The friction effect dealt with here is quite different from other friction effects in indicating instruments.

The separate marking of the limits of the intrinsic error and the limit of the friction effect gives as much information as possible to the user who can compare different instruments with respect to their accuracy and to the total error.



Y_{re} recorded value of the measured quantity
Y_{rm} momentary recorded value of the measured quantity
Y_t true value of the measured quantity
ε_f maximum value of friction effect
e_i intrinsic error
a time
b chart travel
Y measured quantity

Figure 7 — Analysis of friction effect (see Appendix B)



1 deflection of the recording device
2 time
3 chart travel
4 trace of the recording device
5 true value of the measured quantity

Figure 8 — Analysis of friction effect (see Appendix B)

Publications referred to

This standard makes reference to the following British Standards:
BS 1991, *Letter symbols, signs and abbreviations.*
BS 1991-6, *Electrical science and engineering.*
BS 2011, *Method for the environmental testing of electronic components and electronic equipment.*
BS 3939, *Graphical symbols for electrical, power, telecommunications and electronics diagrams.*
BS 4727, *Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms.*
BS 4727-1, *Terms common to power, telecommunications and electronics.*
BS 4727-1:Group 04, *Measurement terminology.*
BS 5164, *Indirect-acting electrical indicating and recording instruments and their accessories.*

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