

CONFIRMED
JANUARY 1993

Specification for

Direct-acting electrical recording instruments and their accessories

UDC 621.317.7.087.6

Confirmed
January 2011

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

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

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

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

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

© BSI 01-2000

First published October 1919
First revision April 1927
Second revision May 1929
Third revision August 1940
Fourth revision February 1975

The following BSI references relate to the work on this standard:
Committee reference ELE/13
Draft for comment 70/23154

ISBN 0 580 08279 2

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	iii
1 Scope	1
2 Definitions	2
3 Classification	10
4 Permissible intrinsic errors and reference conditions related to the measured quantity	11
5 Permissible intrinsic errors and reference conditions related to time-keeping	14
6 Permissible intrinsic errors and reference conditions for accessories	15
7 Permissible limits of variations	16
8 Permissible limits of variations for interchangeable accessories	19
9 Electrical and mechanical requirements of instruments and accessories	19
10 Constructional requirements for instruments and their accessories	27
11 Markings and symbols for instruments and their accessories	27
12 Categories of test	30
Appendix A Concepts	36
Appendix B Friction effect of electrical measuring instruments of the direct acting, continuous line recording type	40
Figure 1 — Determination of maximum value of friction effect	21
Figure 2 — Effective range 8 A to 50 A	36
Figure 3 — Effective range 80 V to 110 V	36
Figure 4 — Effect of temperature	38
Figure 5 — Effect of temperature	38
Figure 6 — Effect of frequency	39
Figure 7 — Analysis of friction effect	41
Figure 8 — Analysis of friction effect	42
Table 1 — Limits of intrinsic error of instruments related to the measured quantity expressed as a percentage of the fiducial value	11
Table 2 — Preconditioning of instruments	12
Table 3 — Reference conditions for the influence quantities related to the measured quantity	13
Table 4 — Reference conditions for voltage, current and power factor related to the measured quantity	14
Table 5 — Limits of intrinsic error related to the time keeping expressed as a percentage of the true elapsed time	14
Table 6 — Reference conditions for the influence quantities related to time-keeping	15
Table 7 — Limits of intrinsic error of an accessory as a percentage of the fiducial value	15
Table 8 — Normal values of the limits of the nominal range of use and allowable variation as a percentage of the measuring class index	17
Table 9 — Permissible limits of variation for a magnetic induction of 0.5 mT	18
Table 10 — Variation due to mounting on a ferromagnetic panel	18
Table 11 — Normal values of the limits of the nominal range of use related to time keeping	19
Table 12 — Relationship between the type of recording instrument, the type of chart driving mechanism and the accuracy class	20

	Page
Table 13 — Overload test of short duration	23
Table 14 — Current factor for overloads of short duration for shunts	24
Table 15 — Value of test voltage	26
Table 16 — Examples of markings related to the reference conditions and nominal ranges of use for instruments and accessories	30
Table 17 — Symbols for marking instruments and accessories	31
Table 18 — Lower limit of effective range	36
Table 19 — Examples of limits of effective range and fiducial values	37
Publications referred to	Inside back cover

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.

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

$$\begin{aligned}\text{NOTE} \quad \text{Rated power factor} &= \frac{\text{rated power}}{\text{rated voltage} \times \text{rated current}} \\ &= \cos \varphi \text{ for sinusoidal quantities only.}\end{aligned}$$

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