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Specification for
**Direct acting indicating electrical
measuring instruments and their
accessories**

Spécification des appareils de mesure électriques
indicateurs à action directe et leurs accessoires

Spezifikation für elektrische Anzeige-Meßgeräte mit direkter Wirkung und
deren Zubehör

BS 89 : 1977

Foreword

This British Standard has been prepared under the authority of the Power Electrical Engineering Standards Committee. It is identical with Publication 51 'Recommendations for direct acting indicating electrical measuring instruments and their accessories' (including Erratum referring to symbol F-33 in Table XI) published by the International Electrotechnical Commission.

Terminology and conventions. The text of the IEC Publication has been accepted as suitable for publication without deviation, as a British Standard. Certain terminology and conventions are used, however, that are not strictly appropriate in a British Standard, and attention is therefore drawn to the following.

Wherever the word 'Recommendations' relating to this publication, appears, it should be interpreted as 'British Standard'.

The erratum slip referring to symbol F-33 in Table XI has been incorporated in this British Standard.

Cross references. For each of the following references to other IEC Publications that are given in the text, there is an appropriate British Standard; these are listed below.

Appropriate British Standard

IEC 50 International Electrotechnical Vocabulary,
50(20) Scientific and industrial measuring instruments

BS 4727 Glossary of electrotechnical, power,
telecommunications, electronics, lighting and colour
terms

Part 1 Terms common to power, telecommunications
and electronics Group 04 Measurement terminology

IEC 414 Safety requirements for indicating and
recording electrical measuring instruments and
their accessories

BS 5458 Safety requirements for indicating and
recording electrical measuring instruments and their
accessories

IEC 27 Letter symbols to be used in electrical
technology

BS 1991 Letter symbols, signs and abbreviations
Part 6 Electrical science and engineering

NOTE. *Textual error.* When adopting the text of the international standard, the printing error given below was noticed. It has been corrected in this British Standard and has been reported to IEC in a proposal to amend the text of the international standard.

Table III. In the heading of column 4, 'Instruments of classes 0.0 ... 5' is deleted and replaced by 'Instruments of classes 0.5 ... 5'.



CONTENTS

	Page
FOREWORD	Inside front cover
 Clause	
1. Scope	3
2. Definitions	4
2.1 General terms	4
2.2 Description of instruments according to their method of operation	7
2.3 Characteristic features of instruments	8
2.4 Rated values	11
2.5 Influence quantities, reference conditions and nominal range of use	12
2.6 Errors and variations	12
2.7 Accuracy, accuracy class and class index	13
3. Classification	13
4. Permissible intrinsic errors and reference conditions for instruments	14
4.1 Limits of intrinsic error	14
4.2 Conditions for the determination of intrinsic errors of instruments	15
5. Permissible intrinsic errors of accessories	18
5.1 Interchangeable accessories	18
5.2 Accessories of limited interchangeability	18
5.3 Non-interchangeable accessories	18
6. Permissible variations of instruments	19
6.1 Limits of variation	19
6.2 Conditions for the determination of the variations	19
6.3 Variation due to the influence of external magnetic induction	19
6.4 Variation due to the influence of external electric field on electrostatic instruments	21
6.5 Variation due to the influence of mounting on ferromagnetic support	22
6.6 Variation due to the influence of mounting on conductive support	22
6.7 Variation due to the influence of unbalanced currents on the performance of polyphase wattmeters (varmeters)	22
6.8 Variation due to the influence of voltage, current and power-factor (active or reactive) for wattmeters (varmeters)	23
6.9 Variation due to the influence of interaction between the different measuring elements of polyphase wattmeters (varmeters)	25
7. Permissible variations for accessories	25
7.1 Interchangeable accessories	25
7.2 Accessories of limited interchangeability	26
7.3 Non-interchangeable accessories	26

8. Further electrical and mechanical requirements of instruments and accessories	26
8.1 Damping	26
8.2 Self-heating	27
8.3 Permissible overloads	27
8.4 Limit conditions of operation for temperature	30
8.5 Voltage tests, insulation tests and other safety requirements	30
9. Constructional requirements	30
9.1 Sealing	30
9.2 Scales	30
9.3 Preferred values	31
9.4 Zero adjustment	31
10. Markings and symbols for instruments and accessories	31
10.1 Markings and symbols for instruments	31
10.2 Locations of markings and symbols for instruments	33
10.3 Markings and symbols for accessories	34
10.4 Identification of terminals	35
10.5 Markings related to the reference conditions and nominal ranges of use for instruments and accessories	35
11. Proof of compliance with this recommendation	36

Appendix

A 1. Effective range, fiducial value	41
A 2. Rated values. Influence quantities. Reference conditions	41
A 3. Reference range. Nominal range of use	42
A 4. Recommended test methods for ammeters, voltmeters, wattmeters and varimeters of classes 0.05...0.2	45
A 5. Reference conditions and nominal ranges of use of power-factor for wattmeters and varimeters	46
A 6. Recommended categories of tests	49
A 7. Combination of several influence quantities	50
A 8. New classification of class 0.5 instruments	50

British Standard Specification for

Direct acting indicating electrical measuring instruments and their accessories

1. SCOPE

1.1 This recommendation applies to direct acting indicating electrical measuring instruments, for direct and alternating currents, viz.:

- ammeters;
- voltmeters;
- single-phase and polyphase wattmeters, varmeters, phasemeters and power-factor * meters (active or reactive);
- frequency meters of pointer and vibrating-reed types;
- ohmmeters.

It applies to multirange and multipurpose instruments of the above types.

It applies to such instruments which incorporate rectifiers or diodes in their measuring circuits and to thermocouple instruments.

It is also applicable to certain accessories used with such apparatus, viz.:

- shunts;
- series resistors and impedances.

Where other accessories are associated with instruments inasmuch as the calibration has been made of the instrument together with the accessory, the recommendation is applicable to the combination of instrument and accessory.

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

1.3 It also applies to instruments, together with their non-interchangeable accessories having electronic devices (other than rectifiers and diodes) as listed in Sub-clauses 1.3.1 to 1.3.3, provided that they are marked with symbol(s) F-20 and/or F-21.

1.3.1 It also applies to instruments, together with non-interchangeable accessories, if any, having neither an incorporated supply source nor needing an external supply source.

Note. — The electronic devices of these instruments are energized by the same circuit as the measuring circuit and will sometimes be used for the protection of the measuring element.

1.3.2 It also applies to 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 influencing the indicated value only, and that the voltage of the source, and any voltage generated from that source, does not exceed the limit of extra-low voltage.

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.

1.3.3 Instruments in which the electronic device is solely used to supply an auxiliary voltage, such as for ohmmeters, provided that the voltage of the source does not exceed the limit of extra-low

* Power-factor, unless otherwise specified, means active power-factor.

voltage. A voltage generated from that source may exceed this limit provided that the maximum current output at the measuring terminals is limited to 5 mA a.c. or 10 mA d.c.

These instruments may have an incorporated supply source or may be fed by an external source.

1.4 Apart from the apparatus listed in Sub-clause 1.3, this recommendation does not apply generally to instruments having electronic devices other than rectifiers and diodes in the measuring circuit, to calibrated generators and/or amplifiers or to instruments with digital presentation.

1.5 This recommendation does not contain requirements for environmental conditions for instruments e.g.:

- weather proof;
- flameproof;
- shock proof;
- vibration proof.

2. DEFINITIONS

The majority of the following definitions have been taken from those given in the International Electrotechnical Vocabulary, Group 20 [IEC Publication 50 (20)], in which case the appropriate IEV reference is given.

2.1 General terms

2.1.1 *Electrical measuring instrument*

An instrument which measures an electrical quantity (IEV 20-05-150).

2.1.2 *Accessory*

Circuit element (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 particular type of instrument.

Here, the recommendation applies to any combination of instrument and accessory of the relevant types of a manufacturer unless otherwise stated. Each of the components of the combination has its own class index.

Instruments intended to be used with these accessories are also considered as having limited interchangeability, and they shall meet the requirements of Sub-clause 5.2.2.

2.1.2.3 *Non-interchangeable accessory*

An accessory adjusted to take into account the electrical characteristics of a specific instrument. The recommendation then applies to the combination of instrument and accessory, and the accessory has no class index of its own.

2.1.3 *Electrically operated measuring equipment*

An equipment using electrical means for the measurement of a non-electrical quantity.

2.1.3.1 *Electrically operated measuring indicating instrument (receiver)*

An electrical measuring instrument used as the indicating means of an electrically operated measuring equipment (IEV 20-05-155 modified).

2.1.4 *Electronic instrument*

An instrument in which the measurement is made by means of an electronic device (IEV 20-05-100).

This definition is applicable both to electronic instruments which measure electrical quantities and to those which measure non-electrical quantities.

2.1.5 *Indicating instrument*

An instrument which indicates, at any time, the instantaneous, effective, average, or peak value of the measured quantity (IEV 20-05-010 modified).

2.1.6 *Direct acting indicating instrument*

An instrument in which the indicating device is mechanically connected to and actuated by the moving element.

2.1.7 *Instrument with contacts*

An instrument in which the moving element operates contacts when it arrives at certain positions (IEV 20-05-185 modified).

2.1.8 *Instrument with magnetic screening*

An instrument shielded from the influence of an external magnetic field by ferro-magnetic material (IEV 20-05-200).

2.1.9 *Astatic instrument*

An instrument of which the moving element is astatic (IEV 20-05-175 modified), i.e., so constructed that it is unaffected by uniform external magnetic fields (IEV 20-35-020 modified).

2.1.10 *Instrument with electrostatic screening*

An instrument provided with screens which protect it from the influence of external electric fields (IEV 20-05-210).

2.1.11 *Measuring circuit*

A complete electrical circuit internal to the instrument and its accessories, together with the interconnecting leads if any, which is energized by a voltage or a current, one or both of these quantities being a prime factor in determining the indication of the measured quantity (one of these quantities may be the measured quantity itself).

2.1.11.1 *Current circuit (series circuit)*

A measuring circuit energized by a current which is a prime factor in determining the indication of the measured quantity.

Note. — It may be the current directly involved in the measurement or a proportional current supplied by a current transformer or derived from a shunt.

2.1.11.2 *Voltage circuit (shunt circuit)*

A measuring circuit energized by a voltage which is a prime factor in determining the indication of the measured quantity.

Note. — It may be the voltage directly involved in the measurement or a proportional voltage supplied by a voltage transformer or a voltage divider or derived by means of a series resistor (impedance).

2.1.12 *Auxiliary circuit*

For the purpose of this recommendation, an auxiliary circuit is a circuit, other than a measuring circuit, required for the operation of the instrument.

2.1.13 *Shunt*

A resistor connected in parallel with an instrument in order to reduce the current which passes through it. The resistance value may be so chosen that the reduction is in a known ratio (IEV 20-35-090).

2.1.14 *Series resistor (impedance)*

A resistor (impedance), connected in series with a voltmeter or the voltage circuit of a measuring instrument, specially to alter its voltage range (IEV 20-35-110 modified).

2.1.15 *Instrument leads*

Conductors specially designed for connecting a measuring instrument to its accessories (IEV 20-35-140 modified).

2.1.16 *Calibrated instrument leads*

Instrument leads as defined in Sub-clause 2.1.15, of which the resistance is adjusted to a specified value.

Calibrated instrument leads are considered as being interchangeable accessories of the measuring instrument.

2.1.17 *Instrument with suppressed zero*

An instrument which displays no useful indication when the quantity to be measured is less than a certain value (IEV 20-05-190 modified).

2.1.17.1 *Instrument with mechanically suppressed zero*

An instrument in which the zero is displaced outside the scale by mechanical means.

2.1.17.2 *Instrument with electrically suppressed zero*

An instrument in which the zero is displaced outside the scale by electrical means.

2.1.18 *Multipurpose instrument*

An instrument in which the measuring circuit(s) is (are) adapted to measure more than one kind of quantity (e.g., current, voltage and power).

2.1.19 *Distortion factor*

The ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the non-sinusoidal quantity (IEV 05-02-120).

2.2 Description of instruments according to their method of operation

2.2.1 *Permanent-magnet moving coil instrument*

An instrument which depends for its operation on the reaction between the current in a movable coil or coils, and the field of a fixed permanent magnet (IEV 20-05-035 modified).

2.2.2 *Moving-magnet instrument*

An instrument in which one or several fixed coils carrying currents actuate a moving magnet or system of magnets (IEV 20-05-050).

2.2.3 *Moving-iron instrument*

An instrument comprising a movable piece of ferromagnetic material which is actuated by a fixed coil carrying a current, or by a fixed piece of ferromagnetic material magnetized by the current (IEV 20-05-040 modified).

2.2.4 *Polarized moving-iron instrument*

An instrument comprising a movable piece of ferromagnetic material actuated by a fixed magnet and by a fixed coil carrying a current (IEV 20-05-045 modified).

2.2.5 *Ironless electro-dynamic instrument*

An instrument which makes use of the force exerted between fixed and moving coils carrying currents and which does not incorporate ferromagnetic material in the magnetic circuit (IEV 20-05-055 modified).

2.2.6 *Iron-cored electro-dynamic instrument (ferrodynamic instrument)*

An instrument in which the electro-dynamic effect is increased by the presence of ferromagnetic material (IEV 20-05-060 modified).

2.2.7 *Induction instrument*

An instrument which makes use of the effect of fixed inductive circuits on currents which they induce in moving conducting elements (IEV 20-05-065).

2.2.8 *Hot-wire instrument*

An instrument in which the expansion of a wire, directly or indirectly heated by a current, is transmitted to the moving element (IEV 20-05-080).

2.2.9 *Bimetallic instrument*

An instrument in which the deformation of a bimetallic element, directly or indirectly heated by a current, is transmitted to the moving element (IEV 20-05-085).

2.2.10 *Thermocouple instrument*

An instrument in which the current heats a thermocouple, the electromotive force from which is measured by a permanent-magnet moving coil instrument (IEV 20-05-095).

2.2.11 *Rectifier instrument*

An instrument that is the combination of an instrument sensitive to direct current and a rectifying device whereby alternating currents (voltages) may be measured (IEV 20-05-105).

2.2.12 *Electrostatic instrument*

An instrument the operation of which depends on electrostatic forces (IEV 20-05-025).

2.2.13 *Vibrating-reed instrument*

An instrument in which reeds resonate under the action of a periodic current flowing through fixed coils, which are sometimes combined with a magnet (IEV 20-05-110 modified).

The reeds may be arranged in one or more rows each comprising a frequency range.

2.2.14 *Ratiometer (quotientmeter)*

An instrument for measuring the ratio (quotient) of two electrical quantities (IEV 20-15-235 modified).

2.2.15 *Polyphase instrument*

An instrument for the measurement of the active or reactive power or power-factor in a balanced or unbalanced polyphase system.

2.2.16 *Balanced load polyphase instrument **

An instrument for the measurement, in a balanced polyphase system, of the active or reactive power or power-factor, and in which the measuring element comprises more than one voltage circuit or more than one current circuit, supplied by voltages or currents of different phases.

2.3 **Characteristic features of instruments**2.3.1 *Measuring element*

The active part of a measuring instrument which includes the parts the interaction between which actuates the moving element (IEV 20-35-050).

2.3.2 *Moving element*

The moving part of an instrument the deflection of which is observed (IEV 20-35-005).

2.3.3 *Index*

The means which, in conjunction with the scale, indicates the position of the moving element of an instrument (IEV 20-35-025 modified).

2.3.4 *Scale*

The series of marks and numbers from which is obtained the value of the measured quantity (IEV 20-35-045 modified).

2.3.4.1 *Non-linear contracting scale*

For the purpose of this recommendation, a non-linear contracting scale (such as a logarithmic or hyperbolic scale), is one in which the scale mark corresponding to the arithmetic mean

* When the measurement of the active or reactive power in a balanced polyphase system is made by means of a single-phase wattmeter which has been calibrated in terms of polyphase power, the instrument shall be considered, for the purpose of this recommendation, as a single-phase instrument with a scale factor.

$C = (A + B)/2$ is situated between 65% and 100% of the scale length corresponding to the effective range.

In this formula, A is the lower limit and B is the upper limit of the effective range.

Note. — All other scales are considered to be non-linear expanding (e.g. quadratic) or linear.

2.3.5 *Scale marks*

A number of marks by which it is possible to determine the position of the index of an instrument (IEV 20-40-005 modified).

2.3.6 *Scale division*

The interval between two consecutive scale marks (IEV 20-40-020 modified).

2.3.7 *Scale numbering*

The series of numbers forming part of the scale (IEV 20-40-010 modified).

2.3.8 *Total scale length*

The total length of the arc (or of the segment of a circle) passing through the centres of the shortest markings on the graduated scale (IEV 20-40-015 modified).

2.3.9 *Dial*

A surface which carries the scale and other marks and symbols (IEV 20-35-040 modified).

2.3.10 *Effective range*

That part of the scale where measurements can be made with the stated accuracy (IEV 20-40-035). For frequency meters with several rows of reeds, each row covers an effective range.

Note. — The requirements concerning the markings of the limits of the effective range are given in Sub-clause 9.2.4.

2.3.11 *Fiducial value*

A value to which the errors of an instrument and/or an accessory are referred in order to specify their accuracy.

2.3.11.1 The fiducial value corresponds to:

- i) The upper limit of the effective range for the following:
 - instruments with the mechanical and/or electrical zero at one end of the scale;
 - instruments with the mechanical zero outside the scale irrespective of the position of the electrical zero;
 - instruments with the electrical zero outside the scale irrespective of the position of the mechanical zero except for instruments covered by paragraph iv);
 - frequency meters of the pointer type;
 - frequency meters of the vibrating reed type. For frequency meters of the vibrating reed type with several rows of reeds, the fiducial value for each row is the upper limit of the effective range of that row.
- ii) The sum of the electrical values, irrespective of sign, corresponding to the two limits of the effective range when both the mechanical and the electrical zeros are displaced within the scale,

iii) 90 electrical degrees for phasemeters and power-factor meters (active or reactive).

iv) The difference of the resistance values corresponding to the two limits of the effective range for linear scale ohmmeters.

2.3.11.2 The fiducial value corresponds to the total scale length for instruments (e.g. ohmmeters) with a non-linear contracting scale and without any separate linear scale.

A number indicating the limit of the error as a percentage of the true value is added when information concerning a part of the scale is to be given. (See Sub-clause 4.1.2.)

2.3.11.3 For instruments (e.g. multipurpose instruments) with a non-linear contracting scale and also a separate linear scale, the fiducial value for the non-linear scale is expressed in one of the following ways:

- a) If only one class mark with symbol E-1 appears on the instrument, it will be understood that for the non-linear contracting scale this class mark is also valid but with the total scale length as the fiducial value;
- b) If, in addition to symbol E-1, symbol E-4 appears, this will have the same significance as in Sub-clause 4.1.2.

2.3.11.4 The fiducial value corresponds to the rated value for

- interchangeable accessories,
- accessories of limited interchangeability.

Note. — For the determination of intrinsic errors, see Sub-clause 5.2.

2.3.12 *Zero and zero adjuster*

2.3.12.1 *Zero scale mark*

The mark on the scale associated with the figure zero.

2.3.12.2 *Mechanical zero*

The equilibrium position which the index will approach when the measuring element (if mechanically controlled) is de-energized. This may or may not coincide with the zero scale mark (IEV 20-40-115 modified).

In mechanically suppressed zero instruments, the mechanical zero does not correspond to a scale mark.

In instruments without mechanical control, the mechanical zero is indeterminate.

2.3.12.3 *Electrical zero*

The equilibrium position which the index will approach when the measured electrical quantity is either zero or a set value and the control circuit (if any), producing a restoring torque, is energized.

2.3.12.4 *Mechanical zero adjuster*

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

2.3.12.5 *Electrical zero adjuster*

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

2.3.12.6 *Residual deflection*

The part of the deflection of a mechanically controlled moving element which remains after the cause producing it has disappeared, and all the measuring circuits are de-energized.

2.4 **Rated values**2.4.1 *Rated value(s)*

Value(s) (or one of the values) which occur(s) in the designation of the instrument.

In all instruments, the rated value of the measured quantity is the value corresponding to the upper limit of the effective range.

In wattmeters and varmeters, the rated values are the designated values of the voltage, current and power-factor (active or reactive).

In phase meters and power-factor meters, the rated values are the designated values of the voltage and current.

In ohmmeters and frequency meters, the voltage of the instrument also has a rated value.

Note. — This does not prevent these values from being associated with a reference range or a nominal range of use (see Sub-clauses 2.5.2.2 and 2.5.3).

2.4.2 *Rated values of shunts*2.4.2.1 *Rated current*

The rated value of a current which flows through the parallel combination of shunt and instrument (see also Sub-clause 5.1 b)).

2.4.2.2 *Rated voltage drop*

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

2.4.3 *Rated current of series resistors (impedances)*

The current assigned by the manufacturer as that which the resistor (impedance) will carry while satisfying the requirements of this recommendation.

2.4.4 *Rated active power-factor ($\cos \phi$) of a wattmeter and rated reactive power-factor ($\sin \phi$) of a varmeter*

The active power-factor ($\cos \phi$) marked on the instrument or — in the absence of marking — the ratio between the power of a wattmeter corresponding to the upper limit of the effective range and the product of the rated voltage and the rated current; this product shall be multiplied by an appropriate constant for polyphase wattmeters.

In instruments for which the above ratio is higher than unity, unity power-factor is assumed as the rated value.

In a varmeter, the rated value of reactive power-factor ($\sin \phi$) is defined by analogy.

Notes 1. — The value of the multiplying constant depends on the type of wattmeter (or varmeter) and on the chosen rated voltage. For instance, the value of the constant, for a two-element wattmeter is equal to $\sqrt{3}$, the rated voltage being chosen as phase to phase; for a three-element wattmeter, or for a single-phase wattmeter with the scale calibrated in three-phase units, the value of the constant is 3, the rated voltage being chosen as phase to neutral.

2. — $\cos \phi$ and $\sin \phi$ can be defined only for a sinusoidal waveform and are used here in that sense.

2.4.5 *Rating (in terms of the measured quantity)*

The value of the quantity which corresponds to the upper limit of the effective range (IEV 20-40-050).

2.5 **Influence quantities, reference conditions and nominal range of use**

2.5.1 *Influence quantity*

A quantity (other than the measured quantity) which is liable to cause unwanted variation in the indications of an instrument and/or in the characteristics of an accessory on which the measurement depends (IEV 20-40-060 modified).

Note. — Generally, it covers such quantities as ambient temperature, position, frequency, external magnetic induction, which quantities are independent of the measured quantity.

For wattmeters and varimeters, voltage, current and power-factor may act as influence quantities since the quantity to be measured by these instruments depends on an infinite number of combinations of values of these quantities. These quantities will have reference ranges and nominal ranges of use which are given in the appropriate tables.

2.5.2 *Reference conditions*

The specified conditions under which the instrument, and/or the accessory, meets the requirements concerning intrinsic errors. These conditions may have either of the following:

2.5.2.1 *Reference value*

A single value of an influence quantity at which (within the tolerance stated in Clauses 4 and 5) the instrument, and/or accessory, complies with the requirements concerning intrinsic errors.

2.5.2.2 *Reference range*

A range of values of an influence quantity within which the instrument, and/or accessory, complies with the requirements concerning intrinsic errors.

2.5.3 *Nominal range of use*

A range of values which each influence quantity can assume without causing a variation exceeding the limits specified in Clause 6 for an instrument or Clause 7 for an accessory.

2.6 **Errors and variations**

Throughout this recommendation, the concept of error is limited to those errors determined when the instrument, and/or accessory, is (are) under reference conditions (see Sub-clause 2.5.2). This concept for error is concerned with the intrinsic qualities of the instrument (e.g. the accuracy of the scale marking) and/or accessory in contradistinction to the variation in indication which may arise from the use of the instrument under conditions other than the reference conditions.*

2.6.1 *Absolute error*

Difference obtained by subtracting the true value of a quantity from its measured value.

2.6.2 *Relative error*

The ratio of the absolute error to the true value of the measured quantity (IEV 20-40-090 modified).

* These considerations are more fully explained in the Appendix.

2.6.3 *Error expressed as a percentage of the fiducial value*

One hundred times the quotient of the absolute error and the fiducial value as defined in Sub-clause 2.3.11.

2.6.4 *Intrinsic error*

An error determined when the instrument and/or accessory is (are) under reference conditions. This concept applies to Sub-clauses 2.6.1, 2.6.2 and 2.6.3. For the purpose of this recommendation, the intrinsic error is the error expressed as a percentage of the fiducial value.

2.6.5 *Variation with influence quantity*

The difference between two measured values of the same measured quantity when an influence quantity assumes successively two different specified values (IEV 20-40-130 modified).

2.6.6 *Variation with influence quantity expressed as a percentage of the fiducial value*

One hundred times the quotient of the variation with influence quantity and the value of the measured quantity corresponding to the fiducial value as defined in Sub-clause 2.3.11.

2.7 **Accuracy, accuracy class and class index****2.7.1** *Accuracy*

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

2.7.2 *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 clauses of this recommendation.

2.7.3 *Class index*

The number which designates the accuracy class.

Notes 1. — The class index is also used to define the limits of some variations.

2. — Multirange and multipurpose instruments may have more than one class index.

3. **CLASSIFICATION**

Instruments and their accessories satisfying the present recommendation are classified as follows:

3.1 **According to their method of operation**

corresponding to one of the definitions of measuring instruments given in Sub-clause 2.2.

3.2 **According to their accuracy class**

as defined in Sub-clause 2.7.2.

3.2.1 **Instruments in one of the following classes:**

0.05 — 0.1 — 0.2 — 0.5 — 1 — 1.5 — 2.5 — 5.

Note. — Class 0.3 may also be used. The requirements concerning classes 0.05 ... 0.2 should be applied to this class.

BS 89 : 1977

3.2.2 Interchangeable shunts, series resistors and impedances in one of the following classes:

0.02 — 0.05 — 0.1 — 0.2 — 0.5 — 1.

This classification is applicable also to accessories with limited interchangeability as defined in Sub-clause 2.1.2.2.

4. PERMISSIBLE INTRINSIC ERRORS AND REFERENCE CONDITIONS FOR INSTRUMENTS

4.1 Limits of intrinsic error

When the instrument, associated with its non-interchangeable accessories, if any, is under the reference conditions given in Tables II, III and IV and is used between the limits of the effective range, the intrinsic error shall not exceed the limits given in table I.

The error shall be expressed as a percentage of the fiducial value (Sub-clause 2.3.11).

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

TABLE I

Limits of intrinsic error expressed as a percentage of the fiducial value

Class index	0.05	0.1	0.2	0.5	1	1.5	2.5	5
Limits of error	±0.05 %	±0.1%	±0.2 %	±0.5%	±1%	±1.5 %	±2.5 %	±5%

Note. — When class index 0.3 is used, the limits of error are $\pm 0.3\%$.

4.1.1 For vibrating reed frequency meters, the following shall also apply:

4.1.1.1 The absolute error is taken as equal to the greatest value of the frequency difference:

- between the nominal frequency of any reed and the frequency at which that reed has its greatest amplitude of vibration; or
- between the mean nominal frequency of two adjacent reeds and the frequency at which these reeds have the same amplitude of vibration.

4.1.1.2 The difference between the nominal frequencies of two adjacent reeds shall not exceed twice the limit of the absolute error.

4.1.2 For instruments with non-linear contracting scales (see Sub-clause 2.3.11.2), the following shall also apply:

- the scale shall carry markings indicating the part of the scale where the error can be expressed as a percentage of the true value. This part of the scale shall be at least 50% of the total scale length.
- in order to convey information about the part of the scale between the markings, a number expressing the limit of the error as a percentage of the true value shall be added to the class index by using symbol E-4 of Table XI.
- within the part of the scale where the errors are expressed as a percentage of the true value, the limit of the error may be greater than that corresponding to the class index but shall not exceed 10%.

4.2 Conditions for the determination of intrinsic errors of instruments

4.2.1 Before the determination of the intrinsic errors, the instrument shall be at the ambient temperature. This temperature shall be the reference temperature (see Table III).

4.2.2 Before the pre-conditioning specified in Table II, the index of instruments having a mechanical and/or an electrical zero shall be adjusted to the appropriate scale mark.

Note. — The recommended test methods for ammeters, voltmeters, wattmeters and varimeters of classes 0.05 ... 0.2 are given in Clause A 4 of the Appendix.

4.2.3 For wattmeters and varimeters of classes 0.5 ... 5, the index shall be adjusted immediately after the rated voltage is applied to the voltage circuit, the current circuit being interrupted in such a way that the potential between the voltage and current circuits is the same as in normal operation.

Note. — The recommended test methods for ammeters, voltmeters, wattmeters and varimeters of classes 0.05 ... 0.2 are given in Clause A 4 of the Appendix.

4.2.4 The instrument shall be left in circuit under the conditions and for the time specified in Table II. Unless otherwise marked, the values of voltage and current are r.m.s. values.

TABLE II
*Pre-conditioning of instruments*¹⁾

Conditions	Instruments of classes 0.05 ... 0.2 ²⁾	Instruments of classes 0.5 ... 5
Voltage (as percentage of rated voltage)	100	100
Current (as percentage of rated current)	80	80
Time between connection into circuit and determination of errors	Any time (for convenience not longer than 1 hour) ³⁾	At least $\frac{1}{2}$ hour, unless otherwise stated by the manufacturer

¹⁾ The reference conditions given in Table III for the influence quantities should be taken into account for the preconditioning of instruments.

²⁾ See Appendix, Clause A 4.

³⁾ For frequency meters, a definite minimum time may be stated by the manufacturer.

4.2.5 The reference conditions relative to most of the influence quantities are given in Table III.

The reference conditions relative to voltage, current and power-factor are given in Table IV.

4.2.6 Any further instructions for use given by the manufacturer shall be taken into account.

4.2.7 For ohmmeters with rotating generators, the speed of the drive shall be within the limits stated by the manufacturer.

These limits shall be those of the nominal range of use, and shall be chosen in such a way that the variation does not exceed one-half of a value corresponding to the class index.