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direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts

ICS 17.220.20

Saudi Standards, Metrology and Quality Org (SASO)

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Foreword

The Saudi Standards ,Metrology and Quality Organization (SASO)has adopted the International standard No. IEC 60051-1:2016 “direct acting indicating analogue electrical measuring instruments and their accessories – Part 1: Definitions and general requirements common to all parts” issued by (IEC). The text of this international standard has been translated into Arabic so as to be approved as a Saudi standard.

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INTRODUCTION

IEC 60051 is published in separate parts according to the following structure and under the general title *Direct acting indicating analogue electrical measuring instruments and their accessories*.

Part 1: Definitions and General Requirements Common to all Parts.

Part 2: Special Requirements for Ammeters and Voltmeters.

Part 3: Special Requirements for Wattmeters and Varmeters.

Part 4: Special Requirements for Frequency Meters.

Part 5: Special Requirements for Phase Meters, Power Factor Meters and Synchroscopes.

Part 6: Special Requirements for Ohmmeters (Impedance Meters) and Conductance Meters.

Part 7: Special Requirements for Multi-function Instruments.

Part 8: Special Requirements for Accessories.

Part 9: Recommended Test Methods.

Parts 2 to 9 are not complete in themselves and shall be read in conjunction with this Part 1.

All of these parts are arranged in the same format and a standard relationship between subject and clause number is maintained throughout. This re-arrangement will assist the reader of IEC 60051 to distinguish information relating to the different types of instruments.

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DIRECT ACTING INDICATING ANALOGUE ELECTRICAL MEASURING INSTRUMENTS AND THEIR ACCESSORIES –

Part 1: Definitions and general requirements common to all parts

1 Scope

This part of IEC 60051 specifies definitions and general requirements for direct acting indicating analogue electrical measuring instruments and their accessories.

This part applies to direct acting indicating analogue electrical measuring instruments, such as:

- ammeters and voltmeters;
- wattmeters and varmeters;
- frequency meters of pointer and vibrating-reed types;
- phasemeters, power-factor meters and synchroscopes;
- ohmmeters(impedance meters) and conductance meters;
- multi-function instruments of the above types.

It also applies to:

- certain accessories used with these instruments, such as:
  - shunts;
  - series resistors and impedance elements;
- combination of the instruments and the accessories provided that the adjustments have been made for the combination;
- direct acting indicating electrical measuring instrument whose scale marks do not correspond directly to its electrical input quantity, provided that the relationship between them is known;
- instruments and accessories having electronic devices in their measuring and/or auxiliary circuits.

These series standards do not apply to:

- special purpose instruments which are covered by their own IEC standards;
- special purpose devices which are covered by their own IEC standards when they are used as accessories.

This standard does not specify requirements concerning dimensions of instruments or accessories (for the former, see IEC 60473).

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60051-9, *Direct acting indicating analogue electrical measuring instruments and their accessories – Part 9: Recommended Test Methods*[1]

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*

IEC 60529:2013, *Degrees of protection provided by enclosures (IP Code)*

IEC 60721-3-3:1994, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weatherprotected locations*
IEC 60721-3-3/AMD1:1995
IEC 60721-3-3/AMD2:1996

IEC 60721-3-7:1995, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 7: Portable and non-stationary use*
IEC 60721-3-7/AMD1:1996

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-2-030:2010*, Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits*

IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 61326-2-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 2-1: Particular requirements – Test configurations, operational conditions and performance criteria for sensitive test and measurement equipment for EMC unprotected applications*

ISO 780:1997*, Packaging – Pictorial marking for handling of goods*

3 Terms and definitions

For the purpose of this standard, the terms and definitions given in IEC 60359 as well as the following, apply.

3.1 General terms

3.1.1
electrical measuring instrument
measuring instrument intended to measure an electrical or non-electrical quantity using electrical or electronic means

[SOURCE: IEC 60359:2001, 3.2.4]

3.1.2
analogue display instrument
measuring instrument intended to present or display the output information as a continuous function of the measured quantity

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1 To be published.

Note 1 to entry: An instrument in which a change of the indication occurs by small discrete steps, but which does not have a digital display, is considered to be an analogue display instrument.

3.1.3
indicating instrument
measuring instrument which displays at any time the value of the measured quantity without recording it

Note 1 to entry: The indicated value may be different from the value of the quantity measured by the instrument and may be in units of a different quantity.

3.1.4
direct acting indicating instrument
instrument in which the indicating device is mechanically connected to and actuated by the moving element

3.1.5
multi-function instrument
instrument having a single means of indication intended for the measurement of more than one kind of quantity (e.g. an instrument measuring current, voltage and resistance)

3.1.6
fixed instrument
measuring instrument designed to be permanently mounted and which is intended to be connected by means of permanently installed conductors

[SOURCE: IEC 60050-300:2001, 312-02-17]

3.1.7
portable instrument
instrument specifically designed to be carried by hand

Note 1 to entry: The instrument is intended to be connected and disconnected by the user.

3.1.8
hand-held instrument
instrument intended to be held by one hand during normal use

3.1.9
panel mounted instrument
fixed installed instrument intended to be mounted in a cut out of a panel or a chassis

[SOURCE: IEC 62586-1:2013, 3.1.6]

3.1.10
polyphase instrument
instrument for measurement in a polyphase system and arranged for connection to more than one phase of the system

3.1.11
astatic instrument
measuring instrument in which the measuring element is, by design, unaffected by uniform magnetic fields of external origin

[SOURCE: IEC 60050-300:2001, 312-02-05]

3.1.12
ammeter
instrument intended to measure the value of a current

[SOURCE: IEC 60050-300:2001, 313-01-01]

3.1.13
voltmeter
instrument intended to measure the value of a voltage

[SOURCE: IEC 60050-300:2001, 313-01-03]

3.1.14
ohmmeter
resistance meter
instrument intended to measure electrical resistance

[SOURCE: IEC 60050-300:2001, 313-01-09]

3.1.15
wattmeter
instrument intended to measure active power

[SOURCE: IEC 60050-300:2001, 313-01-06]

3.1.16
varmeter
instrument intended to measure reactive power

[SOURCE: IEC 60050-300:2001, 313-01-07]

3.1.17
phase meter
instrument which indicates the phase angle between two electrical input quantities of the same frequency and of similar waveform

Note 1 to entry: Such an instrument measures:

– the phase angle between a voltage and another voltage or between a current and another current,

or

– the phase angle between a voltage and a current.

3.1.18
power factor meter
instrument intended to measure the ratio of the active to the apparent power in an electrical circuit

[SOURCE: IEC 60050-300:2001, 313-01-14]

3.1.19
synchroscope
instrument intended to indicate that two alternating voltages or polyphase voltage systems have the same frequency and are in phase

[SOURCE: IEC 60050-300:2001, 313-01-22]

3.1.20
accessory
element, group of elements or device associated with the measuring circuit of a measuring instrument in order to confer specified characteristics to the measuring instrument

3.1.21
interchangeable accessory
accessory having its own properties and accuracy, these being independent of those of the instrument with which it may be associated

Note 1 to entry: 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. A shunt whose adjustment takes into account an instrument current which is not negligible and which is known, is considered to be interchangeable.

3.1.22
accessory of limited interchangeability
accessory having its own properties and accuracy, which can only be associated with measuring instruments for which certain characteristics are within specified limits

3.1.23
non-interchangeable accessory
accessory adjusted to take into account the electrical characteristics of a specific measuring instrument

3.1.24
shunt
resistor connected in parallel with a measuring circuit of a measuring instrument

Note 1 to entry: A shunt is generally intended to provide a voltage proportional to a current to be measured.

3.1.25
series resistor (impedance)
resistor (impedance) connected in series with a measuring circuit of a measuring instrument

Note 1 to entry: A series resistor (impedance) is generally intended to extend the voltage measuring range of an instrument.

3.1.26
instrument lead
lead comprising one or more conductors, specially designed for interconnecting measuring instruments to external circuits or to accessories

3.1.27
calibrated instrument lead
instrument lead whose resistance has a specified value

Note 1 to entry: A calibrated instrument lead is considered as being an interchangeable accessory of a measuring instrument.

3.1.28
distortion factor (total harmonic distortion factor) (of a quantity)
ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the non-sinusoidal quantity

3.1.29
ripple content of a quantity
ratio of the r.m.s. value of the fluctuating component to the value of the d.c. component

3.1.30
peak factor
ratio of the peak value to the r.m.s. value of a periodic quantity

3.2 Description of instruments according to their method of operation

3.2.1
permanent-magnet moving-coil instrument
instrument which operates by the interaction of the magnetic field due to a current in a movable coil with the field of a fixed permanent magnet

Note 1 to entry: The instrument can have more than one coil, measuring the sum or ratio of the currents in them.

3.2.2
moving-magnet instrument
instrument which operates by the interaction of the field of a movable permanent magnet with the magnetic field due to a current in a fixed coil

Note 1 to entry: The instrument can have more than one coil.

3.2.3
moving-iron instrument
instrument which operates by the attraction between a movable piece of soft magnetic material and the field due to a current in a fixed coil or by the repulsion (and attraction) between one (or more) fixed piece(s) of soft magnetic material and a movable piece of soft magnetic material, both (all) magnetized by a current in a fixed coil

3.2.4
polarized moving-iron instrument
instrument comprising a movable piece of soft magnetic material polarized by a fixed permanent magnet and magnetically excited by a current in a fixed coil

3.2.5
electrodynamic instrument
instrument which operates by the interaction of the magnetic field due to a current in a movable coil with the magnetic field due to a current in one or more fixed coils

3.2.6
ferrodynamic instrument (iron-cored electrodynamic instrument)
electrodynamic instrument in which the electrodynamic effect is modified by the presence of soft magnetic material in the magnetic circuit

3.2.7
induction instrument
instrument which operates by the interaction of the magnetic field(s) of (a) fixed a.c. electromagnet(s) with the magnetic field(s) due to currents which they induce in (a) movable conductive element(s)

3.2.8
thermal instrument (electrothermal instrument)
instrument which operates by the heating effect(s) of (a) current(s) on it(s) conductor(s)

3.2.8.1
bimetallic instrument
thermal instrument in which the deformation of a bimetallic element (the materials having different rates of expansion due to a change in temperature), heated directly or indirectly by a current, produces the indication

3.2.8.2
thermocouple instrument
thermal instrument making use of the e.m.f. of one or more thermocouples heated by the current to be measured

Note 1 to entry: The e.m.f. is often measured using a permanent-magnet moving-coil instrument.

3.2.9
rectifier instrument
instrument which is the combination of a measuring instrument sensitive to direct current and a rectifying device whereby alternating currents or voltages may be measured

3.2.10
electrostatic instrument
instrument the operation of which depends on the effects of electrostatic forces between fixed and movable electrodes

3.2.11
pointer-type frequency meter
instrument which indicates the measured frequency by the relationship between an index and a scale

3.2.12
vibrating-reed frequency meter
instrument intended to measure frequency, comprising a set of tuned vibrating reeds, one or a few of which resonate under the action of an alternating current of the relevant frequency flowing through one or more fixed coils

3.2.13
ratiometer (quotientmeter)
instrument for measuring the ratio (quotient) of two quantities

3.2.14
R.M.S.-responding instrument
instrument which, over a specified frequency range, provides an indication which is designed to be proportional to the root-mean-square value of the measured quantity, even when it is not sinusoidal or containing a d.c. part

3.2.15
mean value-responding instrument
instrument with scale of R.M.S value but which, over a specified frequency range, provides an indication which is designed to be proportional to the mean value of the measured quantity

Note 1 to entry: These instruments do not reflect R.M.S. value of a measurand when the measurand is not sinusoidal or containing a d.c. part.

3.3 Constructional features of instruments

3.3.1
measuring circuit (of an instrument)
part of the 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)

3.3.1.1
current circuit
measuring circuit through which flows a current which is a prime factor in determining the indication of the measured quantity

Note 1 to entry: It may be the current directly involved in the measurement or a proportional current supplied by an external current transformer or derived from an external shunt.

3.3.1.2
voltage circuit
measuring circuit to which is applied a voltage which is a prime factor in determining the indication of a measured quantity

Note 1 to entry: It may be the voltage directly involved in the measurement or a proportional voltage supplied by an external voltage transformer or an external voltage divider or derived by means of an external series resistor (impedance).

3.3.2
external measuring circuit
part of the electrical circuit external to the instrument from which a measured value is obtained

3.3.3
auxiliary circuit
circuit, other than a measuring circuit, required for the operation of the instrument

3.3.4
auxiliary supply
auxiliary circuit which provides electrical energy

3.3.5
measuring element
assembly of those parts of a measuring instrument which are acted upon by a measured quantity, resulting in a movement of the moving element related to that quantity

3.3.6
moving element
moving part of a measuring element

3.3.7
indicating device
part of a measuring instrument which displays values of the measured quantity

3.3.8
index
means which, in conjunction with the scale, indicates the position of the moving element of an instrument

3.3.9
scale
series of marks and numbers from which, in conjunction with the index, the value of the measured quantity is obtained

3.3.10
scale marks
marks on the dial for the purpose of dividing it into suitable intervals so that the position of the index may be determined

3.3.11
zero scale mark
mark on the dial associated with the figure zero

3.3.12
scale division
distance between any two consecutive scale marks

3.3.13
scale numbers
series of numbers which are associated with the scale marks

3.3.14
dial
surface which carries the scale and other marks and symbols

3.3.15
mechanical zero
equilibrium position which the index will approach when the measuring element (if mechanically controlled) is de-energized.

Note 1 to entry: This may or may not coincide with the zero scale mark.

Note 2 to entry: In mechanically suppressed zero instruments, the mechanical zero does not correspond to a scale mark.

Note 3 to entry: In instruments without restoring torque the mechanical zero is indeterminate.

3.3.15.1
mechanical zero adjuster
mechanism by means of which the instrument may be adjusted so that the mechanical zero coincides with the appropriate scale mark

3.3.15.2
mechanical span adjuster
mechanism by means of which the instrument may be adjusted so that the lower/upper limit of the measuring range coincides with the appropriate scale mark

3.3.16
electrical zero
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

3.3.16.1
electrical zero adjuster
for an instrument which needs an auxiliary supply, the mechanism by means of which the instrument may be adjusted so that the electrical zero coincides with the appropriate scale mark

3.3.16.2
electrical span adjuster
for an instrument which needs an auxiliary supply, the mechanism by means of which the instrument may be adjusted so that the lower/upper limit of the measuring range coincides with the appropriate scale mark

3.4 Characteristic features of instruments

3.4.1
scale length
length of the line (curved or straight) which passes through the centres of all the shortest scale marks contained between the first and the last scale marks

Note 1 to entry: It is expressed in units of length.

Note 2 to entry: If an instrument has more than one scale, each scale may have its own scale length. For convenience, the scale length of the instrument is taken to be that of the major scale.

3.4.2
span
algebraic difference between the upper and lower limits of the measuring range

Note 1 to entry: It is expressed in units of the measured quantity.

3.4.3
measuring range (effective range)
range defined by two values of the measured quantity within which the limits of uncertainty of a measuring instrument (and/or accessory) are specified

Note 1 to entry: A measuring instrument (and/or accessory) can have several measuring ranges.

3.4.4
residual deflection
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

3.4.5
overshoot
difference between the extreme indication and the steady indication (expressed in terms of the scale length) when the measured quantity is abruptly changed from one steady value to another

3.4.6
response time
time taken for the indication to first reach and then remain within a band centred on the final steady indication when the measured quantity is abruptly changed from zero (the unenergized condition) to a value such that the final steady indication is a specified proportion of the scale length

3.5 Characteristic values

3.5.1
nominal value
value of a quantity indicating the intended use of an instrument or accessory. The intended characteristics of instruments and accessories are also nominal values

3.5.2
rated value
quantity value assigned by a manufacturer for a specified operating condition of the equipment or instrument

Note 1 to entry: A rated value V assigned with an uncertainty U is actually a range V±U and should be handled as such

[SOURCE: IEC 60359:2001, 3.3.8]

3.5.3
fiducial value
clearly specified value of a quantity to which the uncertainty(ies) of an instrument and/or an accessory are referred in order to specify their respective accuracies

Note 1 to entry: This value can be, for example, the upper limit of the measuring range, the span or another clearly stated value.

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

3.6.1
measurand
quantity subjected to measurement, evaluated in the state assumed by the measured system during the measurement itself

Note 1 to entry: The value assumed by a quantity subjected to measurement when it is not interacting with the measuring instrument may be called unperturbed value of the quantity.

Note 2 to entry: The unperturbed value and its associated uncertainty can only be computed through a model of the measured system and of the measurement interaction with the knowledge of the appropriate metrological characteristics of the instrument, that may be called instrumental load.

[SOURCE: IEC 60359:2001, 3.1.1]

3.6.2
influence quantity
quantity which is not the subject of the measurement and whose change affects the relationship between the indication and the result of the measurement

Note 1 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment.

Note 2 to entry: As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lie within the specified range.

Note 3 to entry: An influence quantity is said to lie within a range C' to C" when the results of its measurement satisfy the relationship: C' ≤V-U< V + U≤C".

[SOURCE: IEC 60359:2001, 3.1.14]

3.6.3
reference conditions
appropriate set of specified values and/or ranges of values of influence quantities under which the smallest permissible uncertainties of a measuring instrument are specified

Note 1 to entry: The ranges specified for the reference conditions, called reference ranges, are not wider, and are usually narrower, than the ranges specified for the rated operating conditions.

[SOURCE: IEC 60359:2001, 3.3.10]

3.6.4
reference value
specified value of one of a set of reference conditions

[SOURCE: IEC 60359:2001, 3.3.11]

3.6.5
reference range
specified range of values of one of a set of reference conditions

[SOURCE: IEC 60359:2001, 3.3.12]

3.6.6
nominal range of use or rated operating range (for influence quantities)
specified range of values which an influence quantity can assume without causing a variation exceeding specified limits

Note 1 to entry: The rated operating range of each influence quantity is a part of the rated operating conditions.

[SOURCE: IEC 60359:2001, 3.3.14]

3.6.7
limiting values for operation
extreme values which an influence quantity can assume during operation without damaging the instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

Note 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60359:2001, 3.3.16]

3.6.8
preconditioning
action whereby a specified value of the measured quantity is applied to the measuring circuit prior to carrying out testing or use of the instrument or accessory

3.6.9
storage and transport conditions
extreme conditions which a non-operating measuring instrument can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions

[SOURCE: IEC 60359:2001, 3.3.17]

3.6.10
limiting values for storage
extreme values which an influence quantity can assume during storage without damaging the measuring instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

Note 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60050-300:2001, 311-07-07]

3.6.11
limiting values for transport
extreme values which an influence quantity can assume during transport without damaging the measuring instrument so that it no longer meets its performance requirements when it is subsequently operated under reference conditions

Note 1 to entry: The limiting values can depend on the duration of their application.

[SOURCE: IEC 60050-300:2001, 311-07-08]

3.7 Uncertainty and variations

3.7.1
(absolute) instrumental uncertainty
uncertainty of the result of a direct measurement of a measurand having negligible intrinsic uncertainty

Note 1 to entry: Unless explicitly stated otherwise, the instrumental uncertainty is expressed as an interval with coverage factor 2.

Note 2 to entry: In single-reading direct measurements of measurands having intrinsic uncertainty small with respect to the instrumental uncertainty, the uncertainty of the measurement coincides, by definition, with the instrumental uncertainty. Otherwise the instrumental uncertainty is to be treated as a component of category B in evaluating the uncertainty of the measurement on the basis of the model connecting the several direct measurements involved.

Note 3 to entry: The instrumental uncertainty automatically includes, by definition, the effects due to the quantization of the reading-values (minimum evaluable fraction of the scale interval in analogic outputs, unit of the last stable digit in digital outputs).

Note 4 to entry: For material measures the instrumental uncertainty is the uncertainty that should be associated to the value of the quantity reproduced by the material measure in order to ensure the compatibility of the results of its measurements.

Note 5 to entry: When possible and convenient the uncertainty may be expressed in the relative form (see 3.3.3) or in the fiducial form (see 3.3.4). The relative uncertainty is the ratio U/V of the absolute uncertainty U to the measure value V, and the fiducial uncertainty is the ratio U/V_f of the absolute uncertainty U to a conventionally chosen value V_f.

[SOURCE: IEC 60359:2001, 3.1.12]

3.7.2
conventional value
measure-value of a standard used in a calibration operation and known with uncertainty negligible with respect to the uncertainty of the instrument to be calibrated

Note 1 to entry: This definition is adapted to the object of this standard from the definition of "conventional true value (of a quantity)": value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose.

[SOURCE: IEC 60359:2001, 3.1.13]

3.7.3
intrinsic (instrumental) uncertainty
uncertainty of a measuring instrument when used under reference conditions

[SOURCE: IEC 60359:2001, 3.2.10]

3.7.4
operating instrumental uncertainty
instrumental uncertainty under the rated operating condition

Note 1 to entry: The operating instrumental uncertainty, like the intrinsic one, is not evaluated by the user of the instrument, but is stated by its manufacturer or calibrator. The statement may be expressed by means of an algebraic relation involving the intrinsic instrumental uncertainty and the values of one or several influence quantities, but such a relation is just a convenient means of expressing a set of operating instrumental uncertainties under different operating conditions, not a functional relation to be used for evaluating the propagation of uncertainty inside the instrument.

[SOURCE: IEC 60359:2001, 3.2.11]

3.7.5
limit of uncertainty
limiting value of the instrumental uncertainty for equipment operating under specified conditions

Note 1 to entry: A limit of uncertainty may be assigned by the manufacturer of the instrument, who states that under the specified conditions the instrumental uncertainty is never higher than this limit, or may be defined by standards, that prescribe that under specified conditions the instrumental uncertainty should not be larger than this limit for the instrument to belong to a given accuracy class.

Note 2 to entry: A limit of uncertainty may be expressed in absolute terms or in the relative or fiducial forms.

[SOURCE: IEC 60359:2001, 3.3.6]

3.7.6
variation (due to an influence quantity)
difference between the indicated values for the same value of the measurand of an indicating instrument, or the values of a material measure, when an influence quantity assumes, successively, two different values

Note 1 to entry: The uncertainty associated with the different measure values of the influence quantity for which the variation is evaluated should not be wider than the width of the reference range for the same influence quantity. The other performance characteristics and the other influence quantities should stay within the ranges specified for the reference conditions.

Note 2 to entry: The variation is a meaningful parameter when it is greater than the intrinsic instrumental uncertainty.

[SOURCE: IEC 60359:2001, 3.3.5]

3.8 Accuracy, accuracy class and class index

3.8.1
accuracy
for a measuring instrument, the quality which characterizes the closeness of the indicated value to the true value

for an accessory, the quality which characterizes the closeness of the marked (intended) value to the true value

Note 1 to entry: The accuracy of a measuring instrument or of an accessory is defined by the limits of intrinsic error end by the limits of variations.

3.8.2
accuracy class
class of measuring instruments, all of which are intended to comply with a set of specifications regarding uncertainty

Note 1 to entry: An accuracy class always specifies a limit of uncertainty (for a given range of influence quantities), whatever other metrological characteristics it specifies.

Note 2 to entry: An instrument may be assigned to different accuracy classes for different rated operating conditions.

Note 3 to entry: Unless otherwise specified, the limit of uncertainty defining an accuracy class is meant as an interval with coverage factor 2.

[SOURCE: IEC 60359:2001, 3.3.7]

3.8.3
class index
the number which designates the accuracy class

Note 1 to entry: Some instruments and/or accessories may have more than one class index.

3.9 Test

3.9.1
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.9.2
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.9.3
recurrent test
test, at a defined time interval, carried out for the assessment of electrical safety

4 Description, classification and compliance

4.1 Description

4.1.1 Description according to methods of operation or nature

Instruments and/or accessories shall be described according to their methods of operation or their nature as given in clause 3 and/or by their special characteristics as given in the relevant parts.

4.1.2 Description according to environmental conditions

Instruments and/or accessories shall be described according to their environmental conditions as follows:

- Group A: for use under conditions which are normally found in laboratories and factories and where apparatus will be handled carefully, the nominal range of use for temperature is reference temperature ±10 °C or lower limit of reference range –10 °C and upper limit of reference range +10 °C;

- Group B: for use in environments having protection from full extremes of environment, the nominal range of use for temperature is -5 °C to +45 °C (fixed instrument and/or accessory: class 3K5 according to IEC 60721-3-3:1994, Amendment 2:1996; portable instrument and/or accessory: class 7K2 according to IEC 60721-3-7:1995, Amendment 1:1996);
- Group C: for outdoor use and use under conditions that the ambient temperature changes badly, the nominal range of use for temperature is -25 °C to +55 °C (class 3K6 according to IEC 60721-3-3:1994, Amendment 2:1996).

The nominal range of use for temperature for torrid type instruments should be determined by agreement between manufacturer and customer according to IEC 60721-3-3:1994, Amendment 2:1996.

4.1.3 Description according to mechanical conditions

Based on their mechanical conditions, instruments and/or accessories may be described as class 3M2, class 3M4 (and above), and class 3M6 (and above) according to IEC 60721-3-3:1994, Amendment 2:1996.

4.1.4 Description according to degrees of protection

According to IEC 60529:2013, instruments and/or accessories shall comply with Table 1 as a minimum IP requirement.

Table 1 – Minimum IP requirements

Kind of measuring instrument	Front panel	Housing, except front panel
Fixed installed instrument → panel mounted devices.	IP 40	IP 2X
Portable instrument	IP 40	IP 40

Manufacturer shall state the degrees of protection in the instruction manual.

4.2 Classification

Class indices should be selected from a 1-2-5 sequence and the decimal multiples and submultiples thereof.

In addition, class indices 1,5, 2,5 and 3 may be used for instruments, class index 0,15 for frequency meters and class index 0,3 for accessories.

4.3 Compliance with the requirements of this standard

4.3.1 Instruments and accessories marked with a class index shall comply with the relevant requirements of this standard relating to their class index.

4.3.2 The recommended test methods for checking compliance with the requirements of this standard are given in IEC 60051-9.

In case of dispute, the test methods of IEC 60051-9 are referee methods.

4.3.3 If, for the determination of intrinsic uncertainty preconditioning is specified, the manufacturer shall state the preconditioning period and the value(s) of the measured quantity(ies). The preconditioning period shall not exceed 30 min.

5 Requirements

5.1 Reference conditions

5.1.1 The reference values of the influence quantities should be as given in Table 2.

5.1.2 Reference conditions different from those given in Table 2 may be specified, but they shall then be marked in accordance with Clause 6.

5.1.3 The reference value for the ambient temperature different from those given in Table 2 shall be selected from 20 °C or 27 °C.

5.2 Limits of intrinsic uncertainty, fiducial value

5.2.1 Limits of intrinsic uncertainty

When the instrument together with its non-interchangeable accessory(ies) (if any) or accessory is under the reference condition given in Table 2 and is used between the limits of its measuring range and in accordance with the instruction manuals, the intrinsic uncertainty, expressed as a percentage of the fiducial value, shall not exceed the limits appropriate to its accuracy class. Values stated in a table of corrections supplied with the instrument or accessory shall not be taken into account in determining the uncertainty

NOTE 1 The intrinsic uncertainty includes other uncertainties such as those due to friction, amplifier drift, etc.

NOTE 2 The accuracy classes relating to each type of instrument or accessory are given in the appropriate parts.

5.2.2 Correspondence between intrinsic uncertainty and accuracy class

The maximum permissible uncertainty can be related to the accuracy class such that the class index is used as the limit of uncertainty, expressed as a percentage.

NOTE For example, for a class index of 0,05, the limits of intrinsic uncertainty are ±0,05 % of the fiducial value.

5.2.3 Fiducial value

The fiducial value for each type of instrument and accessory is given in each relevant part.

Table 2 – Reference conditions and tolerances for testing purposes relating to the influence quantities

Influence quantity		Reference conditions unless otherwise marked		Tolerances permitted for testing purposes, applicable for a single reference value [a]	
				Class indices 0,3 and smaller	Class indices 0,5 and greater
Ambient temperature		23 °C		±1 °C	±2 °C
Humidity		Relative humidity 40 % to 60 %		–	–
Ripple of d.c. measured quantity		Ripple content zero		Ripple content 1 %	Ripple content 3 %
Distortion of a.c. measured quantity	Distortion factor	Zero		1) Rectifier instruments, non r.m.s.-responding instruments and instruments which employ phase-shifting networks in their measuring circuits: distortion factor less than or equal to half the class index or 1 % whichever is smaller. 2) Other instruments: distortion factor not exceeding 5 %	
	Peak factor	√2, approx. 1,414 (sine wave)		±0,05	
Frequency of a.c. measured quantity except for frequency meters and instrument with phase-shifting device		45 Hz to 65 Hz		±2 % of the reference value or ± 1/10 of the reference range for frequency (if any), whichever is the smaller	
Position [b]		Fixed instruments: mounting plane vertical Portable instruments: mounting plane horizontal		±1°	
Nature and thickness of panel or support		*Nature*	*Thickness*		
	F-34	Ferrous	X mm	±0,1X mm or ±0,5mm, whichever is smaller	
	F-35	Ferrous	Any	–	
	F-36 [c]	Non-ferrous	Any	–	
	None	Any	Any	–	
Magnetic field of external origin		Total absence		40A/m at frequencies from d.c. to 65Hz in any direction [d]	
Electric field of external origin		Total absence		1kV/m at frequencies from d.c. to 65Hz in any direction	
Electromagnetic RF fields 80MHz to 2GHz		None		<1V/m	
conducted disturbances, induced by radio frequency fields 150kHz to 80MHz		None		<1V	
Auxiliary supply	Voltage	Nominal value or nominal range		±5 % of the nominal value [e]	
	Frequency	Nominal value or nominal range		±1 % of the nominal value [e]	

[a] These tolerances apply when a single reference value is specified in this table or is marked by the manufacturer. For a reference range, no tolerance is allowed.

[b] Instruments provided with a level indicator shall be tested with the instrument set level using the level indicator.

[c] These symbols (or lack of symbol) refer to the nature and thickness of the panel or support on which the instrument is mounted. See Table 6.

[d] 40 A/m is approximately the highest value of the Earth's magnetic field.

[e] Unless a different tolerance is stated by the manufacturer.

5.3 Nominal range of use and variations

5.3.1 Nominal range of use

5.3.1.1 The limits of the nominal range of use for influence quantities shall be as given in Table 3.

5.3.1.2 When a manufacturer assigns and marks a nominal range of use which is different from that shown in Table 3, it shall include the reference range (or reference value with permitted tolerances) and will normally exceed it in at least one direction.

5.3.1.3 For values in the nominal range of use beyond the reference range (or reference value), the permissible variation is as stated in Table 3.

EXAMPLE For an instrument having a class index of 0,2, the variation due to a lack of level of 5° in any direction shall not exceed:

$$0{,}2(\%) \times \frac{50}{100} = 0{,}1\,\%\ \text{of the fiducial value}$$

5.3.1.4 When the influence quantity is not one of those shown in Table 3, the relevant permissible variation shall be stated by the manufacturer and shall not exceed 100 % of the class index.

5.3.1.5 For the instruments and accessories with specified reference range, the intrinsic uncertainty and the variations due to influence quantity in the nominal range of use shall be as given in Annex A.

5.3.1.6 The limits of relative humidity as a function of ambient temperature are shown in Annex B.

Table 3 – Limits of the nominal range of use and permissible variations

Influence quantity		Limits of the nominal range of use unless otherwise marked	Permissible variation expressed as a percentage of the class index
Ambient temperature		Group A: reference temperature ±10 °C or lower limit of reference range –10 °C and upper limit of reference range +10 °C	100 %
		Group B (no marked): –5 °C to +45 °C(fixed type, 3K5; portable type, 7K2),change from reference temperature to lower/upper limit of reference range	
		Group C: –25 °C to +55 °C(3K6)	50 % [a]
Humidity		Relative humidity 25 % to 95 %	100 %
Ripple on d.c. measured quantity		See relevant parts	
Distortion of a.c. measured quantity		Distortion factor: see relevant parts	
		Peak factor: see relevant parts	
Frequency on a.c. measured quantity		See relevant parts	
Position [b]		Horizontal and vertical if the reference position is not marked	100 %
		For instruments with markings D1~D3, 5° in any direction from reference position For instruments with markings D4 and D6, in any direction from value specified by the markings	50 %
Magnetic field of external origin		See 5.3.2.2 and the relevant parts	
Electric field of external origin (electrostatic instruments only)		20kV/m at d.c. and 45Hz to 65Hz. See 5.3.2.3.	100 %
Auxiliary supply	Voltage	Reference value ±10 % or lower limit of reference range –10 % and upper limit of reference range +10 %	50 %
	Frequency	Reference value ±5 % or lower limit of reference range –5 % and upper limit of reference range +5 %	50 %

[a] This is the temperature coefficient which is the permissible variation caused by temperature changed per 10K relative to the reference temperature (reference temperature range) in nominal temperature range.

[b] Instruments provided with a level indicator shall always be set correctly for position using the level indicator. These instruments need not therefore be tested for variation due to position

NOTE For the recommended test, see IEC 60051-9.

5.3.2 Limits of variations

5.3.2.1 General

When an instrument or an accessory is under reference conditions and a single influence quantity is varied, the variation shall not exceed the values given in Table 3 and in 5.3.2.2, 5.3.2.3, 5.3.2.4 and 5.3.2.5.

5.3.2.2 Variation due to a magnetic field of external origin

a) When the instrument is not marked with symbol F-29 (Table 6), the magnetic field strength in the test equipment shall be 0,4 kA/m.

b) For instruments marked with symbol F-29 (Table 6), the magnetic field strength in the test equipment shall have a value in kiloamperes per metre as shown in the symbol.

c) Under the conditions of a) and b), the variation shall not exceed the limits given in the relevant parts.

For the recommended test, see IEC 60051-9.

5.3.2.3 Variation due to an electric field of external origin (electrostatic instruments only)

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

If the instrument is marked with symbol F-32 (Table 6), the field strength is made equal to the value given in the symbol.

For the recommended test, see IEC 60051-9.

5.3.2.4 Variation due to ferromagnetic supports

The uncertainty of instruments which are mounted on a panel of the nature and thickness implied by the relevant symbol F-34, F-35 or F-36 or on a panel of any nature and thickness when not so marked – shall remain within the limits of the intrinsic uncertainty.

There is no requirement of variation due to ferromagnetic support for instruments marked with symbol F-36.

When X in F-34 is different from the value specified in IEC 60051-9, variation due to ferromagnetic supports shall not exceed 50 % of the class index.

For the recommended test, see IEC 60051-9.

5.3.2.5 Variation due to conductive supports

Instruments shall meet the requirements for intrinsic uncertainties relating to their class index when used on a panel or support of high conductivity unless other requirements are given in a separate document and are shown by marking with symbol F-31 (Table 6).

For the recommended test, see IEC 60051-9.

5.3.3 Conditions for the determination of variations

5.3.3.1 If preconditioning is specified for the determination of variations, the manufacturer shall state the preconditioning period and the value(s) of the measured quantity(ies) and of the auxiliary supply, if any.

The preconditioning period shall not exceed 30 min.

5.3.3.2 The variations shall be determined for each influence quantity separately.

During each test all influence quantities shall be maintained at their reference conditions except for the influence quantity for which the variation shall be determined.

5.3.3.3 When an influence quantity has a reference value, the influence quantity shall be varied between that value and any value within the limits of the nominal range of use as given in Table 3, unless otherwise marked.

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

5.4 Operating uncertainty, overall system uncertainty and variations

5.4.1 Under non-reference conditions, the operating uncertainty of an instrument together with its non-interchangeable accessory(ies) (if any) or that of an accessory is the composite of the intrinsic uncertainty and the variations due to every influence quantity. In normal range of use, the maximum operating uncertainty of instrument is the composite of the intrinsic uncertainty and the permissible variations indicated in Table 3. Refer to Annex C for their relationship.

5.4.2 For the instrument used together with its external interchangeable accessory, instrument, accessory and lead constitute a system, and the overall system uncertainty depends on their respective intrinsic uncertainty and variations. Refer to Annex C for their relationship.

5.5 Electrical requirements

5.5.1 Electrical safety requirements

Relevant safety requirements of IEC 61010-1:2010 and IEC 61010-2-030:2010 shall be applied.

5.5.2 Self-heating

5.5.2.1 Instruments, together with their non-interchangeable accessories (if any), interchangeable accessories and accessories of limited interchangeability shall comply with the requirements corresponding to their class index after being continuously operated at any time after the completion of the specified preconditioning period (if any).

For testing:

- instruments shall be energized to give an indication of about 90 % of the upper limit of the measuring range;
- shunts shall be energized at about 90 % of their nominal value;
- series resistors (impedances) shall be energized at about 90 % of their rated values.

5.5.2.2 The variation shall not exceed the value corresponding to 100 % of the class index.

Nonetheless, the instrument, together with its accessories, shall also comply with the requirements relating to its class index.

5.5.2.3 Instruments and accessories intended for intermittent use (e.g. those provided with a non-locking switch) are excluded from the requirements relating to self-heating.

The requirements of 5.5.2.1, 5.5.2.2 and 5.5.2.3 do not apply to ohmmeters.

5.5.2.4 For the recommended test, see IEC 60051-9.

5.5.3 Permissible overloads

5.5.3.1 Continuous overload

Requirements for continuous overload are given in the relevant parts.

5.5.3.2 Overloads of short duration

Requirements for overloads of short duration are given in the relevant parts.

5.5.4 Limiting range of temperature

5.5.4.1 Limiting range for operation

Unless otherwise specified, instruments and/or accessories shall operate without incurring permanent damage when subjected to the ambient temperatures stated below:

- Group A: -5 °C to + 45 °C (7K2);
- Group B: -25 °C to + 55 °C (3K6);
- Group C: -40 °C to + 70 °C (3K7);
- Instruments which incorporate batteries: -25 °C to + 55 °C (3K6);
- Torrid type: the operating range of temperature may be determined by agreement between the user and manufacturer.

5.5.4.2 Limiting range for storage and transport

The non-operating instrument and/or accessories during their storage or transport shall withstand the temperature with – 40 °C to + 70 °C without damage and without degradation of their metrological characteristics when they are subsequently operated under its rated operating conditions.

5.5.4.3 Absence of permanent damage is inferred if, on return to reference conditions, the instruments and/or accessories comply with the requirements relating to intrinsic uncertainty. Adjustment of the instrument zero is permissible.

5.5.4.4 For the recommended test, see IEC 60051-9.

5.5.5 Deviation from zero

Requirements for deviation from zero and for return to zero are given in the relevant parts.

5.5.6 Electromagnetic compatibility (EMC)

The requirements for electromagnetic compatibility according to IEC 61326-1:2012 and IEC 61326-2-1:2012 shall be applied.

Immunity requirements shall be selected from Table 1 of IEC 61326-1:2012 for portable instruments and from Table 2 of IEC 61326 -1:2012 for fix installed instruments.

Emission requirements according Clause 7 of IEC 61326-1:2012 shall be applied only for instruments and accessories with emitting electronic components in their measuring and /or auxiliary circuits. The essential information of the emitting electronic components, as basis for

determining whether or not to carry out emission test, shall be given by the manufacturer in a separate document.

5.6 Constructional requirements

5.6.1 General constructional requirements

An instrument and/or an accessory shall not cause a danger to the operator when in service and under normal operating conditions.

All parts which may be subject to corrosion under normal operating conditions shall be protected effectively. Under normal operating conditions, any protective coating shall not be liable to damage by ordinary handling nor due to exposure to air.

The instruments and/or accessories for group C shall withstand solar radiation.

NOTE For special instruments and accessories used in corrosive atmospheres, additional requirements are stated in the purchase contract (e.g. salt mist test according to IEC 60068-2-11).

5.6.2 Damping

5.6.2.1 General

The damping of instruments, except for instruments having an intentionally long response time, and unless otherwise specified in the relevant part, shall comply with the following requirements.

5.6.2.2 Overshoot

For instruments having a total angular deflection of less than 180°, the mechanical overshoot shall not exceed 20 % of the scale length. For other instruments, the limit shall be 25 %.

For the recommended test, see IEC 60051-9.

5.6.2.3 Response time

Unless otherwise agreed between the manufacturer and the user, the departure of the index from the position of rest shall not exceed 1,5 % of the scale length at any time after 4 s following the sudden application of an excitation producing a change of final indication of two-thirds of the scale length

For the recommended test, see IEC 60051-9.

5.6.2.4 Impedance of the external measuring circuit

When the characteristics of the circuit into which the instrument is connected may affect the damping, the external circuit impedance shall be as stated in the relevant part or otherwise specified by the manufacturer.

5.6.3 Sealing to prevent access

When the instrument is sealed, access to the measuring element and to the accessories within the case shall not be possible without destroying the seal.

5.6.4 Scales

5.6.4.1 Scale divisions

The intervals shall correspond to 1, 2 or 5 times the unit of the measured or indicated quantity or that unit multiplied or divided by 10 or 100.

For multi-range and/or multi-scale instruments, the above requirements shall be fulfilled for at least one measuring range or scale.

The divisions shall be appropriate to the index of class of the instrument, namely the uncertainty of estimate value by visual shall not exceed the specification for class index.

5.6.4.2 Scale numbering

The numerals of the scale (whole number or decimal) marked on the dial should preferably not have more than three digits. SI units and their prefixes should be used in association with the scale numbering.

5.6.4.3 Direction of deflection

The direction of deflection of the index of an instrument shall be from left to right or from bottom to top with increasing measured quantity.

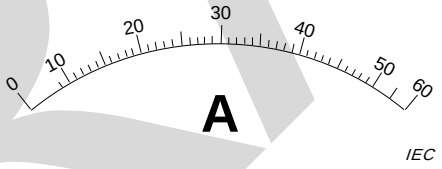
When the angular deflection of the index exceeds 180°, the deflection with increasing measured quantities should be clockwise.

On multi-scale instruments, at least one of the scales shall be such as to comply with the above requirements.

5.6.4.4 Limits of the measuring range

5.6.4.4.1 If the measuring range does not occupy the whole scale length, the limits of the measuring range shall be clearly identified.

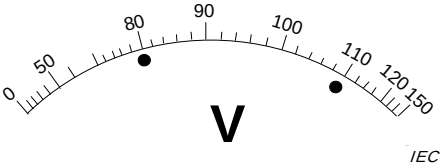
5.6.4.4.2 When the value of the scale divisions or the nature of the scale marks enables the measuring range to be identified with minimal ambiguity, no marking is necessary. An example of this method is given in Figure 1.



NOTE Subdivisions are omitted outside the measuring range.

Figure 1 – Measuring range 10 A to 50 A

5.6.4.4.3 When there is only one scale and marking is necessary, the limits of the measuring range shall be identified by means of small filled-in dots. An example of this method is given in Figure 2.



NOTE The measuring range is ●...●.

Figure 2 – Measuring range 80 V to 110 V

5.6.4.4.4 When there is more than one scale and marking is necessary, the limits of the measuring range shall be identified either by small filled-in dots or by means of widened scale arcs. An example of this latter method is given in Figure 3.

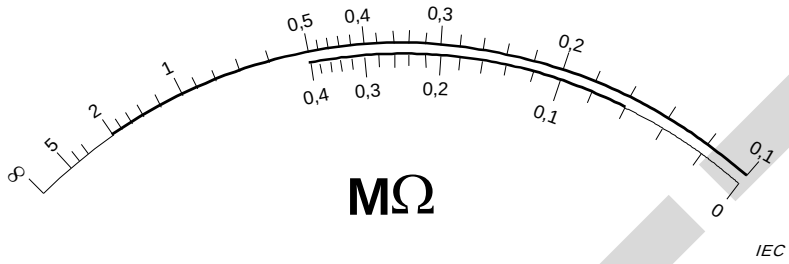


Figure 3 – Measuring ranges 0,06 MΩ to 0,4 M Ω and 0,1 MΩ to 2 MΩ

5.6.5 Stopper

The positions of stopper of an instrument shall not be coincident with that of upper and lower scale marks of measuring range. The length of stopper outside the scale shall be not less than 2 % of the scale length.

5.6.6 Preferred values

The preferred values shall be used in the absence of a special agreement between the manufacturer and the user.

Requirements for preferred values are given in the relevant parts.

5.6.7 Adjusters, mechanical and/or electrical

5.6.7.1 Zero adjuster(s)

When an instrument is fitted with zero adjuster(s), intended for use by the user, it is preferable that it(they) be accessible from the front of the case.

The total range of adjustment shall be not less than 2 % of the scale length or 2°, whichever is the less, and the fineness of setting shall be appropriate to the class index of the instrument.

NOTE By "appropriate", it is understood that the fineness of the setting is such as to permit seeing to within 1/5 of the class index.

For instruments where the effective centre of rotation cannot readily be determined, the requirement relating to 2° is not applicable.

The ratio between the higher and lower ranges of adjustment on either side of the zero mark shall not be greater than 2.

For the recommended test, see IEC 60051-9.

5.6.7.2 Span adjuster(s)

When an instrument is fitted with span adjuster(s), intended for use by the user, it is preferable that it(they) be accessible from the front of the case.

The total range of adjustment shall be not less than 2 % of the scale length or 2°, whichever is the less, and the fineness of setting shall be appropriate to the class index of the instrument.

NOTE By “appropriate", it is understood that the fineness of the setting is such as to permit setting to within 1/5 of the class index.

For instruments where the effective centre of rotation cannot readily be determined, the requirement relating to 2° is not applicable.

The ratio between the higher and lower ranges of adjustment on either side of the zero mark shall not be greater than 2.

For the recommended test, see IEC 60051-9.

5.6.8 Effects of vibration and shock

5.6.8.1 Vibration test

Unless otherwise specified, instruments and accessories of class indices 1 and greater shall be capable of withstanding the vibration test specified in IEC 60051-9.

The variation due to the effect of vibration shall not exceed a value corresponding to 100 % of the class index.

The recommended test, see IEC 60051-9.

5.6.8.2 Shock test

Unless otherwise agreed, instruments and accessories of class indices 1 and greater shall be capable of withstanding the shock test specified in IEC 60051-9.

The variation due to the effect of shock shall not exceed a value corresponding to 100 % of the class index.

The recommended test, see IEC 60051-9.

5.6.9 Degrees of protection provided by enclosure

The test specified in IEC 60529:2013 shall be carried out for instruments and/or accessories according to the IP code of the degrees of protection provided by enclosures. After the test, any ingress of water, dust and solid objects etc. shall be only in a quantity not impairing the operation of the meter and its dielectric strength.

The recommended test, see IEC 60051-9.

5.6.10 Terminals

5.6.10.1 Terminals, fixed screws and steady brace etc. of instrument and accessory shall use the construction and manner of fixing the conductors to the terminals to ensure adequate and durable contact such that there is no risk of loosening or undue heating.

5.6.10.2 The diameter of conductive screw and the diameter of contact surface (or an area of contact surface) shall not be less than the relevant value specified in Table 4 for the rated current through them.

Table 4 – The diameters of conductive screw and the diameters or the area of contact surface

Rated current A	Screw diameter	Diameter of contact surface	Area of contact surface
	mm (not less than)		mm^2 (not less than)
$I \leq 10$ [a]	M3	6	20
$I \leq 20$	M4	8	36

20 < I ≤ 50	M5	10	57
50 < I ≤ 1 00	M6	12	83
100 < I ≤ 200	M8	16	100
[a] Apply to micro-type meters and signal terminals.			

6 Information, markings and symbols

6.1 Information

The following information shall be given by the manufacturer:

a) Unit(s) of measured quantity(ies).

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

c) Type reference, if any, given by the manufacturer.

d) Serial number for instruments and accessories of class indices 0,3 and smaller. Serial number or date of manufacture (at least the year) for instruments and accessories of class indices 0,5 and greater.

e) Rated value(s).

f) Nature of measured quantity(ies) and number of measuring elements.

g) Accuracy class(es).

h) Reference value or reference range for temperature for instruments and accessories of class indices 0,3 and smaller.

i) Reference value(s) or reference range(s) for each influence quantity (other than temperature) given in Table 2 if different from the values given in Table 2 and the reference values or reference ranges for any other relevant influence quantities not given in Table 2.

j) Nominal ranges of use for the influence quantities of Table 3 if the values are different. Nominal ranges of use for any other relevant influence quantities not given in Table 3.

k) Value of acceleration.

l) Instructions for the use of the instrument and/or accessory(ies) when necessary.

m) Method of operation of the instrument.

n) The burden expressed in voltamperes at nominal current and/or nominal voltage.

o) Peak factor.

p) Where relevant, reference position and nominal range of use for position.

q) Temperature limits and other requirements for transport, storage and use, if necessary.

r) For an instrument whose scale marks do not correspond directly to its electrical input quantity, the relationship between them. This does not apply to an instrument having a non-interchangeable accessory.

s) Preconditioning period if not negligible and the value(s) of the measured quantity(ies) to be used for preconditioning.

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

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

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

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

x) Statement concerning an intentionally long response time, if relevant.

y) The nature of the auxiliary supply, rated voltage and rated frequency of the auxiliary supply, if relevant.

z) The overvoltage category specified according to IEC 61010-1:2010: I,II,III or IV for mains circuits; and the measurement category specified according to IEC 61010-2-030:2010: I,II,III or IV for measurement input circuits.

aa) Pollution degree.

bb) Degrees of protection provided by enclosures.

cc) The used environment groups.

dd) Any other essential information.

6.2 Markings, symbols and their locations

6.2.1 The symbols specified in Table 6 shall be used, where relevant. The markings and symbols shall be and remain legible and indelible. SI units, together with their prefixes, shall be marked using the symbols given in 6.4. Marking on the dial shall not impede the clear reading of the scale.

6.2.2 The following information in 6.1 shall be marked on the dial or on a part which is visible while the instrument/accessory is in use:

- a);
- f) (symbol(s) B-1 ... B-9);
- g) (symbol(s) E-1 and E-4);
- p) (symbol D-1 ... D-6);
- z) (symbol according to IEC 61010-1:2010, 6.7.1.5);
- cc) (group A and group C should be marked, group B should not be marked);
- dd) (symbol F-31 if some other essential information is given in a separate document).

6.2.3 The following information in 6.1 shall be marked on the dial or anywhere on the case:

- b); c); d); h);
- m) (symbol(s) F-1 ... F-21, F-26, F-27, F-28, if relevant);
- t) (symbol F-22 ... F-25);
- u);
- where relevant, the nature and thickness of the panel or support (symbol F-34 ... F-36).
- In addition, if the reference values of the influence quantities are different from those given in Table 2, they shall be marked as follows:
  - magnetic field of external origin (symbol F-29 and if relevant F-27 and/or F-28),
  - electric field of external origin (symbol F-32 and if relevant F-26).

6.2.4 The following information in 6.1 shall be marked on the dial or anywhere on the case or given in a separate document (if any):

- b); c); e); i); j); k); l);n); q); r); s); v); w); aa); bb); cc).
- o) (only for instruments containing electronic devices in their measuring circuits);
- x) (by agreement between the manufacturer and the user).

6.2.5 Markings for accessories and special markings for instruments, together with their locations, are given in the relevant parts.

6.2.6 By agreement between the manufacturer and the user, any or all of the information may be omitted.

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

6.3.1 Where a reference value or a reference range is different from that given in Table 2 it shall be marked and shall be distinguished by being underlined. It is identified by the symbol of the unit in which it is measured.

6.3.2 When a nominal range of use is different from that given in Table 3 it shall be marked.

The marking is carried out in conjunction with marking the reference value or reference range. This then requires the marking of the reference value or reference range even if it would not otherwise be necessary.

6.3.3 The marking is done by writing the limits of the nominal range of use and the reference value (or range) in ascending order, each number separated from its neighbour by three dots.

EXAMPLE 1 35 Hz ... 50 Hz ... 60 Hz implies a reference frequency of 50 Hz and a nominal range of use for frequency from 35 Hz to 60 Hz.

EXAMPLE 2 35 Hz ... 45 Hz ... 55 Hz ... 60 Hz implies a reference frequency range from 45 Hz to 55 Hz and a nominal range of use for frequency from 35 Hz to 60 Hz.

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

EXAMPLE 1 23 °C ... 23 °C ... 37 °C implies a reference temperature of 23 °C and a nominal range of use for temperature from 23 °C to 37 °C.

EXAMPLE 2 20 °C ... 20 °C ... 25 °C ... 35 °C implies a reference temperature range from 20 °C to 25 °C and a nominal range of use for temperature from 20 °C to 35 °C.

6.4 The symbols for marking instruments and accessories

The symbols for units of measurement and their prefixes are given in Table 5.

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

EXAMPLE 23 °C, 120 mV.

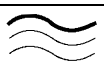
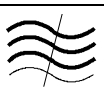
Table 5 – Units, quantities and SI prefixes

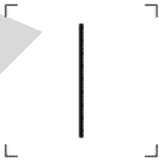
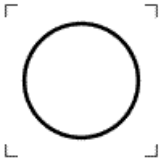
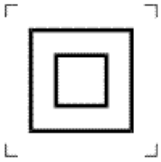
Units and quantities		SI prefixes		
Item	**Symbol**	**Item**		**Symbol**
ampere	A	exa	10^{18}	E
decibel	dB	péta	10^{15}	P
hertz	Hz	téra	10^{12}	T
ohm	Ω	giga	10^{9}	G
second	s (lower case)	méga	10^{6}	M (capital)
siemens	S (capital)	kilo	10^{3}	k (lower case)
tesla	T	hecto [a]	10^{2}	h (lower case)

volt	V (capital)	déca [a]	10	da (lower case)
voltampere	VA (capitals)	déci [a]	10^{-1}	d (lower case)
voltampere reactive	var (lower case)	centi [a]	10^{-2}	c (lower case)
watt	W (capital)	milli	10^{-3}	m (lower case)
power factor	PF	micro	10^{-6}	µ
degree Celsius	°C	nano	10^{-9}	n
		pico	10^{-12}	p
		femto	10^{-15}	f
		atto	10^{-18}	a
[a] These items are non-preferred and their use should be avoided.				

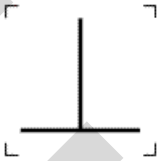
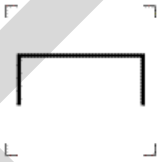
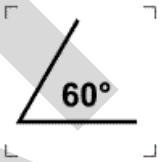
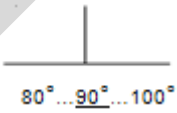
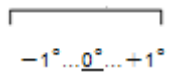
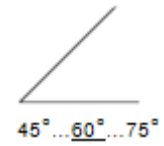
The symbols for marking instruments and accessories are given in Table 6.

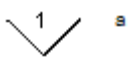
Table 6 – Symbols for marking instruments and accessories

B Nature of measured quantity and number of measuring elements			
No.	**Item**	**Symbol in use**	**Former symbol**
B-1	Direct current circuit and/or d.c. responding measuring element (IEC 60417-5031:2002-10)		
B-2	Alternating current circuit and/or a.c. responding measuring element (IEC 60417-5032:2002-10)		
B-3	Direct and/or alternating current circuit and/or d.c.and a.c. responding measuring element (IEC 60417-5033:2002-10)		
B-4	Three-phase alternating current circuit (general symbol) (IEC 60417-5032-1:2002-10)		
B-5	One measuring element (E) for three-wire network	3 ~ 1E	
B-6	One measuring element (E) for four-wire network	3N ~ 1E	
B-7	Two measuring elements (E) for three-wire network with unbalanced loads	3 ~ 2E	
B-8	Two measuring elements (E) for four-wire network with unbalanced loads	3N ~ 2E	
B-9	Three measuring elements (E) for four-wire network with unbalanced loads	3N ~ 3E	

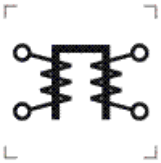
C Safety		
No.	**Item**	**Symbol**
C-1	Earth (ground) terminal (IEC 60417-5017:2006-08)	
C-2	Protective conductor terminal (IEC 60417-5019:2006-08)	
C-3	Frame or chassis terminal (IEC 60417-5020:2002-10)	
C-4	Equipotentiality (IEC 60417-5021:2002-10)	
C-5	On (Power) (IEC 60417-5007:2002-10)	
C-6	Off (Power) (IEC 60417-5008:2002-10)	
C-7	Equipment protected throughout by double insulation or reinforced insulation (IEC 60417-5172:2003-02)	
C-8	Caution, possibility of electric shock (IEC 60417-6042:2010-11)	
C-9	Caution, hot surface (IEC 60417-5041:2002-10)	
C-10	In position of a bi-stable push control (IEC 60417-5268:2002-10)	

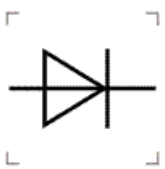
C Safety		
No.	**Item**	**Symbol**
C-11	Out position of a bi-stable push control (IEC 60417-5269:2002-10)	

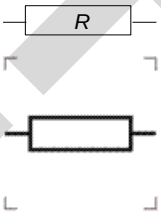
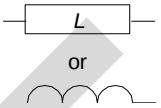
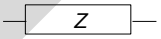
D Position of use		
D-1	Instrument to be used with the dial vertical (IEC 60417-6264:2014-04)	
D-2	Instrument to be used with the dial horizontal (IEC 60417-6265:2014-04)	
D-3	Instrument to be used with the dial inclined (e.g. 60°) from the horizontal plane (IEC 60417-6266:2014-04)	
D-4	Example for instrument to be used as D-1, nominal range of use from 80° to 100°	
D-5	Example for instrument to be used as D-2, nominal range of use from –1° to +1°	
D-6	Example for instrument to be used as D-3, nominal range of use from 45° to 75°	

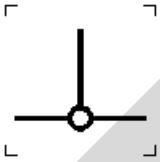
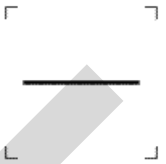
E Accuracy class		
E-1	Class index (e.g. 1) except when the fiducial value corresponds to the scale length or the indicated value or the span	1
E-2	Class index (e.g. 1) when the fiducial value corresponds to the scale length	
E-3	Class index (e.g. 1) when the fiducial value corresponds to the indicated value	
E-4	Class index (e.g. 1) when the fiducial value corresponds to the span	

F General symbols (see also IEC 60417)		
F-1	Permanent-magnet moving-coil instrument (IEC 60417-6267:2014-04)	

F General symbols (see also IEC 60417)		
F-2	Permanent-magnet ratiometer (quotientmeter) (IEC 60417-6268:2014-04)	
F-3	Moving permanent-magnet instrument (IEC 60417-6270:2014-04)	
F-4	Moving permanent-magnet ratiometer (quotientmeter) (IEC 60417-6271:2014-04)	
F-5	Moving-iron instrument (IEC 60417-6272:2014-04)	
F-6	Polarized moving-iron instrument (IEC 60417-6269:2014-04)	
F-7	Moving-iron ratiometer (quotientmeter) (IEC 60417-6273:2014-04)	
F-8	Ironless electrodynamic instrument (IEC 60417-6274:2014-04)	
F-9	Iron-cored electrodynamic (ferro-dynamic) instrument (IEC 60417-6275:2014-04)	
F-10	Ironless electro-dynamic ratiometer (quotientmeter) (IEC 60417-6276:2014-04)	
F-11	Iron-cored electro-dynamic (ferro-dynamic) ratiometer (quotientmeter) (IEC 60417-6277:2014-04)	

F General symbols (see also IEC 60417)		
F-12	Induction instrument (IEC 60417-6278:2014-04)	
F-13	Induction ratiometer (quotientmeter) (IEC 60417-6279:2014-04)	
F-14	Bimetallic instrument (IEC 60417-6280:2014-04)	
F-15	Electrostatic instrument (IEC 60417-6281:2014-04)	
F-16	Vibrating-reed instrument (IEC 60417-6282:2014-04)	
F-17	Non-insulated thermocouple (thermal converter) [b] (IEC 60417-6283:2014-04)	
F-18	Insulated thermocouple (thermal converter) [b] (IEC 60417-6284:2014-04)	
F-19	Electronic device in a measuring circuit [b] (IEC 60417-6323:2015-03)	
F-20	Electronic device in an auxiliary circuit [b] (IEC 60417-6324:2015-03)	
F-21	Rectifier [b] (IEC 60417-5186:2002-10)	

F General symbols (see also IEC 60417)		
F-22	Shunt (IEC 60417-6322:2015-03)	
F-23	Series resistor (IEC 60417-6321:2015-03)	
F-24	Series inductor	
F-25	Series impedance	
F-26	Electric screen	
F-27	Magnetic screen	
F-28	Astatic instrument	ast
F-29	Magnetic field strength expressed in kiloamperes per metre, producing a variation corresponding to the class index (e.g. 2kA/m)	 kA/m
F-30	Zero (span) adjuster (IEC 60417-6285:2014-04)	
F-31	Refer to a separate document, caution (ISO 7000-0434A:2004-01)	
F-32	Electric field strength expressed in kilovolts per metre, producing a variation corresponding to the class index (e.g. 10kV/m)	 kV/m
F-33	General accessory [c]	
F-34	Ferrous support of thickness X mm	FeX
F-35	Ferrous support of any thickness	Fe
F-36	Non-ferrous support of any thickness	NFe
F-37	Noiseless earth (ground) terminal (IEC 60417-5018:2011-07)	

F General symbols (see also IEC 60417)		
F-38	Signal low terminal (IEC 60417-5173:2002-10)	
F-39	Positive terminal (IEC 60417-5005:2002-10)	
F-40	Negative terminal (IEC 60417-5006:2002-10)	
F-41	Resistance range setting control	
F-42	Overload protection device fitted (IEC 60417-6286:2014-04)	
F-43	Overload protection device reset control	

G Groups of environmental conditions		
G-1	Instrument used in laboratory	
G-2	Instrument used outdoor or under conditions that the ambient temperature changes badly	

[a] Symbol E-2 is given for information only. It shall not be used on new designs of instruments.

[b] If symbols F-17, F-18, F-19, F-20 or F-21 are combined with a symbol of an instrument, such as symbol F-1, the device is incorporated.

[c] Symbol F-33 denotes that a device is external and shall be combined with one of the symbols F-17, F-18, F-19, F-20 or F-21.

6.5 Markings and symbols for terminals

6.5.1 Requirements for markings

6.5.1.1 The marking shall be applied on or adjacent to the relevant terminal.

6.5.1.2 If there is insufficient space adjacent to a terminal for the marking specified, a permanently attached nameplate shall be provided having details of the terminals and identifying them in an unambiguous way.

6.5.1.3 The markings shall be and remain legible and indelible and of a colour which contrasts with the background or shall be moulded.

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

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

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

6.5.1.7 The measuring circuit terminals for potable and hand-held instruments shall be marked with the symbol of measurement category and shall be adjacent to the relevant terminals. The symbol F-31 shall be marked on a visible place for panel mounted instruments and shall be stated in the instruction of the instruments.

6.5.2 Earthing (grounding) terminals

6.5.2.1 Terminals which are required to be connected to a protective earth (ground) for reasons of safety shall be marked with symbol C-2 (Table 6).

6.5.2.2 Terminals which are required to be connected to a noiseless earth (ground) to prevent impairment of performance shall be marked with symbol F-37 (Table 6).

6.5.2.3 Terminals which are connected to accessible conductive material but which are not necessarily required to be connected to earth (ground) shall be marked with symbol C-3 (Table 6).

6.5.3 Measuring circuit terminals

If a terminal of a measuring circuit is intended to be kept at or near to earth (ground) potential (e.g. for safety or functional reasons), it shall either be marked with a capital N if it is intended to be connected to the neutral conductor of an a.c. supply circuit, or shall be marked with symbol F-38 (Table 6) in all other circumstances.

These markings are additional to and shall follow any other markings prescribed for the relevant terminal.

6.5.4 Special markings for terminals

Special markings are given in the relevant parts.

6.6 Instructions for use

The instructions shall include following information:

- Brief description for the principle of measurement;
- Measuring method;
- Connection diagrams;
- Type of battery(ies)/ rechargeable cells (if necessary);

- Information on the charging current, charging voltage and duration of charging for rechargeable cells (if necessary);
- Operational lifetime/runtime of the battery /rechargeable cells or the possible number of measurements(if necessary);
- Degrees of protection provided by enclosures(IP code, IEC 60529:2013);
- Any required information excepted the information specified in 6.2.2 and b), c), d), h), m) specified in 6.2.3;
- All information which may be omitted according to 6.2.7;
- If a hazard could be caused by an incorrect reading when measuring or indicating, the instructions shall provide guidance on how to determine that the equipment is functioning correctly.
- Any other necessary special guidance notes.

7 Package

7.1 Instruments and accessories shall be adequately packed to ensure that, after transporting to the user, under normal conditions specified, they comply with the requirements of this standard relating to their class index.

7.2 The external package shall be marked relevant symbols for handling of goods specified in ISO 780:1997.

8 Test rules

8.1 Type of test

Three types of test are required: type tests, routine tests and recurrent tests.

8.2 Type tests

Type test shall be made on a single specimen or on a small number of specimens of each design selected by the manufacturer to verify that the respective type of instrument meets all the requirements of this standard for the relevant class of instrument.

8.3 Routine tests

Routine tests shall be made on all products to verify the products made by the manufacturer conform to the partial main requirements specified in this part and supplemented in relevant parts.

Some routine tests are given in Annex D.

Some routine tests may be supplemented in the relevant parts.

8.4 Recurrent tests

Recurrent tests are usually made periodically during the life of an instrument or an accessory to ensure electrical safety is continued.

The applicable tests as listed in Clause 5.5.1 shall be used for recurrent test.

The values found in these tests shall be documented together with the measuring method and shall be assessed. The values measured shall not exceed the acceptable limit

The period of recurrent test shall be specified in the accompanying documents.

=

8.5 Nonconformity classification

Nonconformity can be classified such as: class A, class B and class C. The weight of class A is 1, the weight of class B is 0,6, the weight of class C is 0,2. Nonconformity classification of tests is given in Annex A of IEC 60051-2 to 8.

8.6 Judgement of test results

During the test, if weight of nonconformity class A or other class translating to A of any specimen is accumulatively no less than 1, the specimen is a nonconforming item. Unless otherwise stated, the nonconformity which repeats on the same test of the same specimen is considered as one.

Annex A
(normative)

Limits of intrinsic uncertainty and variations

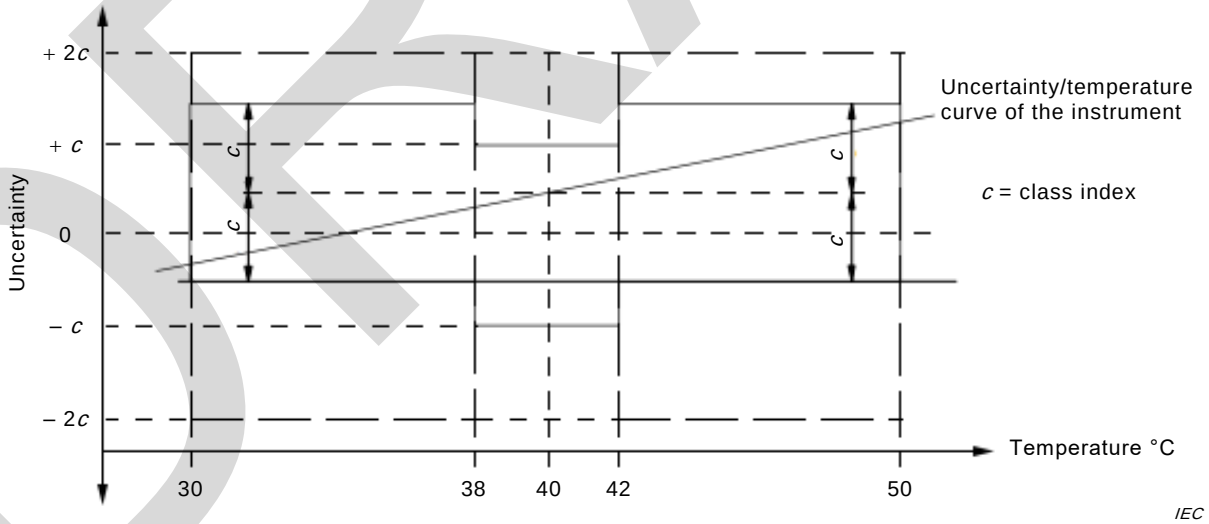
A.1 When an instrument or an accessory is operated under reference conditions, it is permitted to have an uncertainty (the intrinsic uncertainty) no greater than that implied by its class index, for example, for a class 0,5 instrument, the intrinsic uncertainties are not permitted to exceed 0,5 % of the fiducial value.

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

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

A.4 For example, an instrument having a class index of 0,5 and a reference temperature of 40 °C, marked as 40 °C in accordance with 6.3.1, is permitted to have an intrinsic uncertainty of ±100 % of the class index, at the reference temperature and over the testing tolerance of ±2 °C (see Table 2) around 40 °C.

A.5 In addition, over the nominal range of use for temperature of 30 °C to 50 °C (reference temperature is 40 °C), this instrument is permitted to have a variation of ±100 % of the class index around the value of the uncertainty which it had at the reference temperature (40 °C). It is thus possible for the instrument to have a smaller uncertainty at some temperature within the nominal range of use than it had at the reference temperature.



NOTE 1 Reference value: 40 °C.

NOTE 2 Nominal range of use (Table 3): 30 °C to 50 °C.

Figure A.1 – Effect of temperature

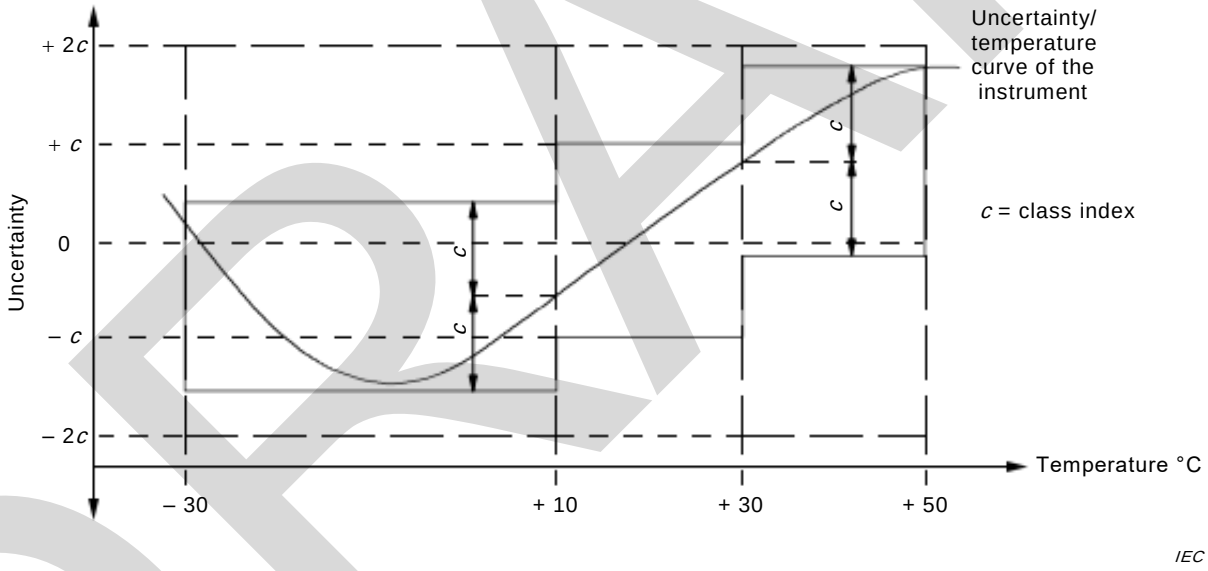
A.6 Figure A.1 shows how the uncertainty of this instrument is permitted to alter with temperature, the class index being shown as *c*.

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

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

A.9 For temperature influence quantity of group A and group B, the variation due to influence quantities changes from the reference temperature to the upper and lower of nominal temperature range. For temperature influence quantity of group C, the variation is a temperature coefficient. The permissible variation of an instrument or an accessory caused by the temperature influence quantity changed per 10K from the reference temperature (the reference temperature range) is the value of ±50 % of the class index, in nominal temperature range.

A.10 Figure A.2 is an example of an instrument having a class index of 0,5 and marked – 30 °C ... +10 °C ... +30 °C ... +50 °C in accordance with 6.3.4 (reference range for temperature +10 °C to +30 °C; nominal range of use for temperature –30 °C to +50 °C) is permitted to have an intrinsic uncertainty of ±100 % of the class index over the temperature range +10 °C to +30 °C.



NOTE 1 Reference range: +10 °C to +30 °C (different from Table 2).

NOTE 2 Nominal range of use: –30 °C to +50 °C (different from Table 3).

Figure A.2 – Effect of temperature

A.11 In addition, over the nominal range of use of –30 °C to +10 °C, a variation is permitted of ±100 % of the class index centred on the uncertainty which the instrument had at +10 °C. Similarly, a variation of ±100 % of the class index, centred on the uncertainty which the instrument had at +30 °C is permitted over the nominal range use from +30 °C to +50 °C.

A.12 If, as is likely in practice, more than one influence quantity is simultaneously outside its reference condition, the resultant uncertainty is unlikely to exceed the sum of the separate variations and may be smaller than any of them, as the resulting uncertainties may to some extent cancel each other.

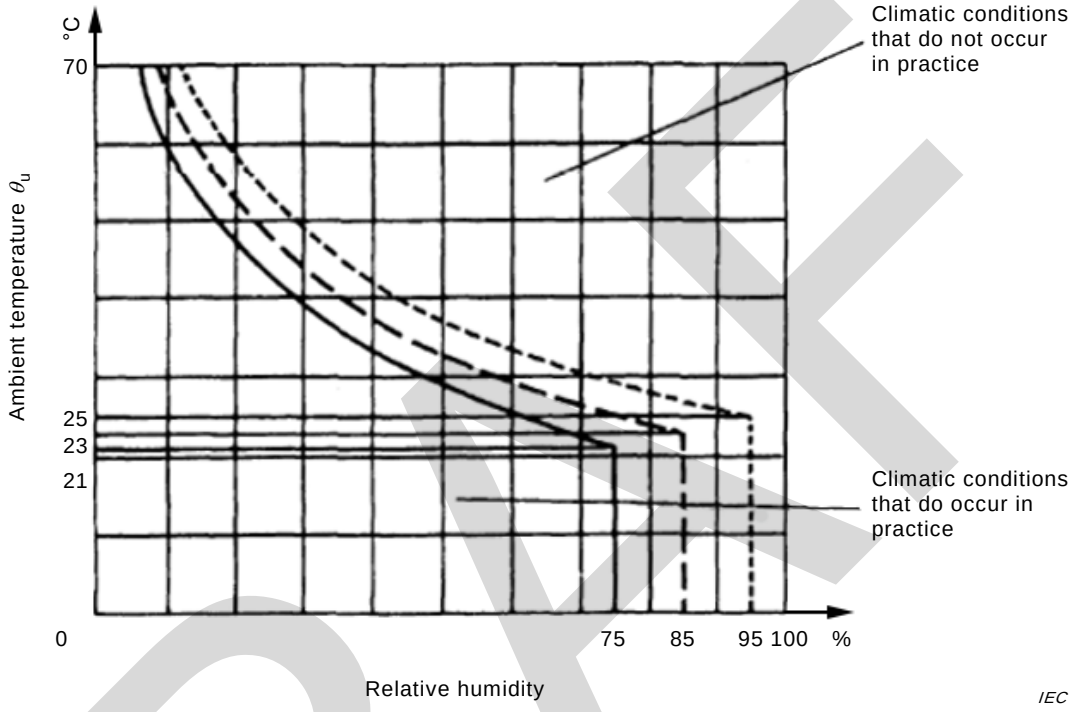
A.13 Information about the simultaneous effect of several influence quantities can usually only be determined by carrying out tests for particular combinations of values of influence quantities. The manufacturer may sometimes be able to provide this information.

A.14 Manufacturers usually may not be able to provide the information about the simultaneous effect of several or all of influence quantities. Users can evaluate the maximum permitted operating uncertainty using the formula given in Annex C.

Annex B
(informative)

Relationship between ambient temperature and relative humidity

The relationship between ambient temperature and relative humidity is shown in Figure B.1.



– – – – – – – – – – Limits for each of 30 days spread in a natural manner over one year

— — — — Limits occasionally reached on other days

_____ Annual mean

Figure B.1 – Relationship between ambient temperature and relative humidity

Annex C
(informative)

Estimation of uncertainties

C.1 Uncertainties in this standard

Uncertainties described in this part of IEC 60051 are shown in Figure C.1.

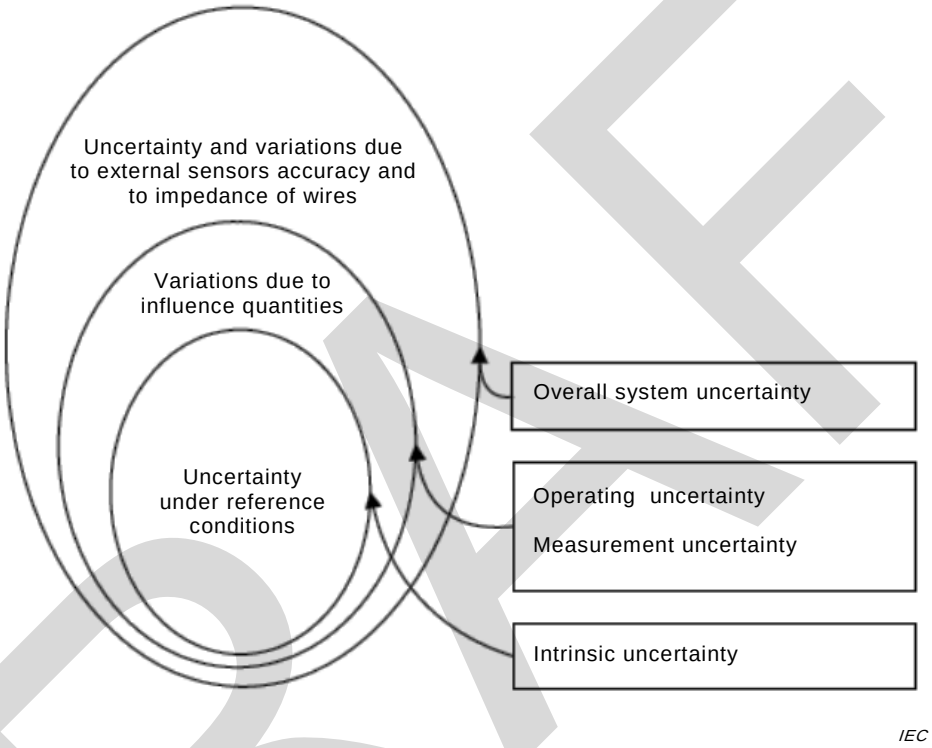


Figure C.1 – Different kinds of uncertainty

C.2 Operating uncertainty

C.2.1 General

Operating uncertainty shall include intrinsic uncertainty (under reference conditions) and the variations due to influence quantities. The users have two ways to estimate the maximum operating uncertainty of instrument in use. One way is to estimate according to type test data provided by the manufacturer, the other way is to estimate according to limit of intrinsic uncertainty and limit of variations due to every influence specified by this standard relating to their class index.

C.2.2 Estimating absolute operating uncertainty according to type test results

Operating uncertainty shall include intrinsic uncertainty (under reference conditions) and the variations due to influence quantities.

When manufacturers provide type test data, absolute operating uncertainty can be estimated using Formula C.1. Intrinsic uncertainty has dependency with each influence quantity, the variations obtained from type test can be treated as rectangular distribution, and the influence quantities are mutually independent. The operating uncertainty is expanded uncertainty which

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has a coverage factor of 2 (corresponding to a coverage probability of approximately 95 %), then:

$$U_{\text{op}} = U_{\text{int}} + 2\sqrt{\frac{V_1^2}{\sqrt{3}^2} + \frac{V_2^2}{\sqrt{3}^2} + \ldots\ldots + \frac{V_n^2}{\sqrt{3}^2}}$$

$$U_{\text{op}} = U_{\text{int}} + 1{,}15\sqrt{\sum_{i=1}^{n} V_i^2} \qquad \text{(C.1)}$$

Where:

U_{op} absolute operating uncertainty;

U_{int} absolute intrinsic uncertainty;

V_i variations due to every influence (in rated operating range), which are determined in the test;

i the number of variations;

n the quantities of variations.

C.2.3 Estimating absolute operating uncertainty according to limit of intrinsic uncertainty and limit of variations due to every influence specified by this standard

Without a manufacturer's type test data, absolute operating uncertainty can be estimated according to the limit of intrinsic uncertainty and the limit of variations due to every influence specified by this part of IEC 60051 relating to the class index, using Formula C.2.

In addition, intrinsic uncertainty is related to influence quantities, and influence quantities are mutually independent. The limits of variations specified by this part of IEC 60051 can be treated as Gaussian distribution. Operating uncertainty is expanded uncertainty which has a coverage factor of 2 (corresponding to a coverage probability of approximately 95 %). The limits of variations specified by this standard have a coverage factor of 2, so half of the variation limit is considered as the standard uncertainty. Then:

$$U_{\text{op}} = U_{\text{int}} + 2\sqrt{\frac{V_1^2}{2^2} + \frac{V_2^2}{2^2} + \ldots\ldots + \frac{V_n^2}{2^2}}$$

$$U_{\text{op}} = U_{\text{int}} + \sqrt{\sum_{i=1}^{n} V_i^2} \qquad \text{(C.2)}$$

Where:

U_{op} is the absolute operating uncertainty obtained from this standard;

Ui_{nt} is the absolute intrinsic uncertainty specified by this standard;

V_i is the variations due to every influence (in rated operating range), which are specified in Table 3 and related parts of this standard;

i is the number of variations;

n is the quantities of variations.

C.3 Overall system uncertainty

The overall system uncertainty of an instrument with external accessory(ies) such as shunt, resistor and impedance shall include the operating uncertainty of the instrument, the uncertainty of the impedance of wires and the operating uncertainty of accessory(ies)

Formula (C.3) is a simplified approach, and applies only to voltage, current, active power, reactive power, power factor and phase measurements:

$$U_S = 1{,}15\sqrt{U_{op}^2 + \sum_{i=1}^{N}(U_a + U_w)^2} \quad \text{(C.3)}$$

Where:

U_S overall system uncertainty;

U_{op} absolute operating uncertainty of an instrument;

U_a absolute operating uncertainty of interchangeable accessory;

U_w absolute uncertainty of impedance of wires;

N the quantities of accessories;

i the number of transducer or wires.

C.4 Fiducial operating uncertainty

According to 3.7.1, Note 5, the fiducial uncertainty is the ratio U/V_f of the absolute uncertainty U to a conventionally chosen value V_f. So, the fiducial operating uncertainty expressed in percentage shall be determined using Formula C.4:

$$U_F = \frac{U_{abs}}{F}100\% \quad \text{(C.4)}$$

Where:

U_F fiducial operating uncertainty;

U_{abs} absolute operating uncertainty;

F fiducial value.

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Annex D
(normative)

Routine Tests

General routine tests shall be carried out on all products according to specified items below:

- Test for intrinsic uncertainty (subclause 5.2);
- Test for variation due to position (subclause 5.3; Table 3);
- The voltage test shall be performed on all the instruments and accessories which have both hazardous live parts and accessible conductive parts (subclause 5.5.1);

NOTE Measuring terminals of rack- mounted and panel-mounted meter under normal operating conditions are not considered as accessible parts.

- Test for return to zero (subclause 5.5.5);
- Other tests supplemented in relevant parts.

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