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Electrical static meters for secondary metering and sub-metering – Specification

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Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 May 2010. It was prepared by Technical Committee SEM/1, *Energy Management*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes DD 8431:2005, which is withdrawn.

Information about this document

This British Standard is based on BS EN 61036 (now superseded by BS EN 62052 and BS EN 62053) and applies to all electrical energy meters for general industrial and commercial applications (such as energy management, compliance with aspects of building regulations, etc.). It provides a basis by which such meters can be specified and described, and their performance evaluated and compared with standardized specifications.

This British Standard does not apply to meters within the scope of BS EN 62052 and BS EN 62053. Those standards are specifically written to specify the requirements of utility metering while this specification applies to sub-meters for general commercial and industrial applications.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Introduction

Energy meters, commonly kWh meters, are a common requirement of electrical control panels, in many cases as part of a multiple function unit. Energy measurement is recognized as an essential element of energy management, part of the overall drive to reduce carbon emissions and to improve the commercial efficiency of manufacturing, commercial organizations and public services.

Although the basic principles of energy management are well understood, for energy to be well managed it needs to be adequately measured. With the common use of electronic equipment, and of electronically controlled loads, the measurement techniques to measure such loads are not generally understood. The effects of incorrect measurement techniques are even less well understood. Unless energy meters are correctly specified, there is a risk that readings obtained in good faith could be incorrect and misleading.

1 Scope

This British Standard specifies requirements for newly manufactured electronic secondary meters or sub-meters which measure either electrical energies alone or electrical energies together with other electrical parameters associated with the energy. It applies to meters that measure active energy, apparent energy, reactive energy (capacitive, inductive and/or total), and ampere squared hours (A^2h) and to the measurement of current, voltage, active power, apparent power, reactive power (capacitive, inductive and/or total), power factor, phase angle and frequency when measured in addition to an energy.

It applies to all secondary meters and sub-meters for indoor and outdoor applications, both portable and permanently installed, for all power frequencies including d.c. It also applies to all registers, indicators, displays and outputs, and to the operation of test outputs.

It does not apply to primary meters, to data interfaces to the meter, or to load survey analysers or load survey meters. The reliability aspect is not covered in this standard.

NOTE 1 Primary meters are covered by BS EN 62052 and BS EN 62053.

NOTE 2 Load survey analysers are instruments that might measure some or all of the parameters and estimate one or more energies but do not conform to the requirements of a meter as defined in this standard and other standards.

Where the display and/or the memory is external or where other elements are enclosed in the meter case (such as maximum demand indicators, telemetering, time switches or remote control, etc.) this standard applies only to the section of the meter concerned with measurement.

NOTE 3 Tests are included in this Standard in the following annexes:

- *Annex A, Tests of mechanical requirements;*
- *Annex B, Tests of climatic influences;*
- *Annex C, Tests of electrical requirements;*
- *Annex D, Tests for electromagnetic compatibility (EMC);*
- *Annex E, Tests of accuracy requirements;*
- *Annex F, Tests of safety requirements.*

Annex G contains a recommended test schedule.

2 Normative references

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

BS EN 55022, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

BS EN 60068-2-1, *Environmental testing – Part 2-1: Tests – Tests A: Cold*

BS EN 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

BS EN 60068-2-5:2000, IEC 60068-2-5:1975, *Environmental testing – Part 2: Tests – Test Sa: Simulated solar radiation at ground level*

BS EN 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

BS EN 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

BS EN 60359, IEC 60359, *Electrical and electronic measurement equipment – Expression of performance*

BS EN 60529, *Specification for degrees of protection provided by enclosures (IP code)*

BS EN 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

BS EN 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

BS EN 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

BS EN 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

BS EN 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

BS EN 61000-4-18, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory waves immunity test*

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

BS EN 61010-2-030:2010, IEC 61010-2-30:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits* [1)]

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1) It is anticipated that BS EN 61010-2-030 and the revision of BS EN 61010-1 will be published in 2010. Up-to-date information can be obtained from BSI Customer Services.

ISO 7000:2004, *Graphical symbols for use on equipment – Index and synopsis*

IEC 60050 (300), *International electrotechnical vocabulary – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements; Part 312: General terms relating to electrical measurements; Part 313: Types of electrical measuring instruments; Part 314: Specific terms according to the type of instrument*

3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS EN 60359 and IEC 60050 (300) and the following apply.

3.1 active power

NOTE Active power is measured in watts.

3.1.1 fundamental active power

product of the r.m.s. values of the fundamental frequency components of voltage and current multiplied by the cosine of the phase angle between them

NOTE The fundamental frequency is also known as the first harmonic frequency.

3.1.2 net active power

average value of the instantaneous power

NOTE 1 Instantaneous power is the product of the instantaneous values of voltage and current. This is often less than the fundamental active power, being the power supplied by the generator minus any harmonic power exported by the load. For practical purposes, the average is taken over an integral number n of cycles of period T.

NOTE 2 An alternative definition is that net active power is the arithmetic sum over all frequency components present (not necessarily only harmonics) of the power at each frequency, given by the product of the r.m.s. values of voltage and current components at that frequency times the cosine of the phase angle between them.

3.2 apparent power

NOTE 1 Apparent power is measured in VA.

NOTE 2 As apparent power is an unsigned quantity, if a sign (or direction) is to be assigned to apparent power, it is essential that this is the sign of the corresponding active power, fundamental or total as applicable.

3.2.1 fundamental apparent power

product of the r.m.s. values of the fundamental frequency components of voltage and current

3.2.2 total apparent power

product of the r.m.s. values of current and voltage

NOTE This definition applies to sinusoidal or other waveforms in a single phase circuit.

3.2.3 derived apparent power

square root of the active power squared plus the reactive power squared

NOTE 1 Derived apparent power, S, is calculated using the following equation:

$$S = \sqrt{P^2 + Q^2}$$

where P is the active power and Q is the reactive power.

NOTE 2 The term active power can refer to fundamental active power or net active power unless a specific active power is stated. Reactive power can refer to fundamental reactive power or non-active reactive power unless a specific reactive power is stated.

NOTE 3 This definition applies to sinusoidal or other waveforms in a single phase circuit.

3.3 reactive power

NOTE Reactive power is measured in var.

3.3.1 fundamental reactive power

product of the r.m.s. values of the fundamental frequency components of voltage and current multiplied by the sine of the phase angle between them

3.3.2 non-active reactive power

square root of the apparent power squared minus the total active power squared

NOTE 1 Non-active reactive power, Q, is calculated using the following equation:

$$Q = \sqrt{S^2 - P^2}$$

where S is the total apparent power and P is the net active power.

NOTE 2 Apparent power is calculated from r.m.s. values of voltage and current. Net active power includes harmonics.

NOTE 3 As non-active power is an unsigned quantity, if a sign is to be assigned, it is essential that this sign is that of the fundamental reactive power.

3.4 ampere squared power

square of the r.m.s. value of current

NOTE 1 Ampere squared power is calculated using one of the following equations:

$$A^2 = \frac{\mathrm{d}}{\mathrm{d}t}\int i^2 \mathrm{d}t \text{ or } A^2 = \frac{\delta}{\delta\tau}\sum_{0}^{t} i^2$$

where i is the instantaneous value of the current and t is time.

NOTE 2 Ampere squared power is measured in A^2.

3.5 polyphase active power

algebraic sum of the active powers of the phases

NOTE The term active power can refer to fundamental active power or net active power unless a specific active power is stated.

3.6 polyphase apparent power

sum of the apparent powers of the phases

NOTE 1 The term apparent power can refer to fundamental apparent power, total apparent power or derived apparent power unless a specific apparent power is stated.

NOTE 2 The following equations can be used to calculate the polyphase apparent power, ΣS:

$$\Sigma S = \sqrt{(\Sigma P)^2 + (\Sigma Q)^2} \quad (1)$$

$$\Sigma S = \Sigma(|S_1| + |S_2| + ...) \quad (2)$$

$$\Sigma S = |\Sigma(S_1 + S_2 + ...)| \quad (3)$$

$$\Sigma S = S_1 + S_2 + ... \quad (4)$$

where P is the active power, Q is the reactive power, S is the apparent power and S_1 and S_2 are single phase values of S.

3.7 polyphase reactive power

NOTE The term reactive power can refer to fundamental reactive power or non-active reactive power unless a specific reactive power is stated.

3.7.1 fundamental polyphase reactive power

algebraic sum of the fundamental reactive powers of the individual phases

3.7.2 non-active reactive polyphase power

square root of the polyphase apparent power squared minus the polyphase total active power squared

NOTE 1 Non-active reactive polyphase power, Q, is calculated using the following equation:

$$Q = \sqrt{S^2 - P^2}$$

where S is the polyphase total apparent power and P is the polyphase net active power.

NOTE 2 Where equations (3) or (4) are used for the derivation of polyphase apparent power, and where individual phase values of VA have been assigned different signs, the value obtained for polyphase non-active power might not be valid.

3.8 polyphase ampere squared power

sum of the individual phase ampere squared values

3.9 energies

3.9.1 energy

integral of power with respect to time

NOTE 1 The term power can refer to active power, apparent power, reactive power or ampere squared power unless a specific power is referred to.

NOTE 2 Energy is integrated over one or more cycles of the supply frequency, or in the case of d.c. over a specified time.

NOTE 3 Integration might be subject to different treatment dependent on the direction of energy transfer. According to the sign of the measured quantity, a register used for its integration might increment, decrement or remain unchanged. Accordingly, for the purpose of recording energy transfers in different directions, more than one register can be used and specified.

3.9.2 active energy

NOTE Active energy is measured in watt hours (Wh).

3.9.2.1 active energy in a single phase circuit

time integral of the active power

NOTE The term active power can refer to fundamental active power or net active power unless a specific active power is stated.

3.9.2.2 active energy in a polyphase circuit
time integral of the polyphase active power

NOTE The term polyphase active power can refer to fundamental polyphase active power or net active polyphase power unless a specific polyphase active power is stated.

3.9.3 apparent energy
NOTE Apparent energy is measured in VA-hours (VAh).

3.9.3.1 apparent energy in a single phase circuit
time integral of the apparent power

NOTE The term apparent power can refer to fundamental apparent power, total apparent power or derived apparent power unless a specific apparent power is stated.

3.9.3.2 apparent energy in a polyphase circuit
time integral of the polyphase apparent power

NOTE The term polyphase apparent power can refer to fundamental polyphase apparent power, total polyphase apparent power or derived polyphase apparent power unless a specific polyphase apparent power is stated.

3.9.4 reactive energy
NOTE Reactive energy is measured in var-hours (varh).

3.9.4.1 fundamental reactive energy in a single phase circuit
time integral of the fundamental reactive power

3.9.4.2 fundamental reactive energy in a polyphase circuit
time integral of the polyphase fundamental reactive power

3.9.4.3 non-active reactive energy in a single phase circuit
time integral of the non-active reactive power

3.9.4.4 non-active reactive energy in a polyphase circuit
time integral of the polyphase non-active reactive power

3.9.5 ampere squared energy
NOTE Ampere squared energy is measured in ampere squared hours (A^2h).

3.9.5.1 ampere squared energy in a single phase circuit
time integral of the ampere squared power

3.9.5.2 ampere squared energy in a polyphase circuit
time integral of the polyphase ampere squared power

3.10 meters and meter components

3.10.1 static meter
meter in which current and voltage act on solid state elements to produce an output or outputs proportional to one or more electrical quantities

NOTE 1 Solid state elements are also known as electronic elements.

NOTE 2 The term meter can refer to a watt-hour meter, a VA-hour meter, a var-hour meter, an ampere squared hour meter or a meter which measures multiple energies unless a specific energy meter is stated.

3.10.2 watt-hour meter

instrument measuring active energy by integrating active power with respect to time

NOTE 1 Adapted from IEC 60050:2001, IEV 301-04-17.

NOTE 2 The term active power can refer to fundamental active power or net active power, single phase or polyphase, unless a specific active power is stated.

3.10.3 VA-hour meter

instrument measuring apparent energy by integrating apparent power with respect to time

NOTE The term apparent power can refer to fundamental apparent power, total apparent power or derived apparent power, single phase or polyphase, unless a specific apparent power is stated.

3.10.4 var-hour meter

instrument measuring reactive energy by integrating reactive power with respect to time

NOTE Reactive power can refer to fundamental reactive power or non-active reactive power, single phase or polyphase, unless a specific reactive power is stated.

3.10.5 ampere squared hour meter

instrument measuring ampere squared energy by integrating ampere squared power with respect to time

3.10.6 multi-rate meter

energy meter provided with a number of registers, each becoming operative at specified time intervals corresponding to different tariffs

[IEC 60050:2001, IEV 302-04-06]

NOTE The term energy meter can refer to a watt-hour meter, VA-hour meter, var-hour meter or ampere squared hour meter or a meter which measures multiple energies unless a specific energy meter is stated.

3.10.7 meter type

particular design of meter, manufactured by one manufacturer, having similar metrological properties, the same uniform construction of parts determining these properties and the same ratio of maximum current to basic current

NOTE 1 The meter type might have several values of basic current and reference voltage. Meters are designated by the manufacturer by one or more groups of letters or numbers, or a combination of letters and numbers. Each type has one designation only.

NOTE 2 The meter type is represented by the sample meter(s) intended for the type tests, whose characteristics (basic current and reference voltage) are chosen from the values given in the tables proposed by the manufacturer.

3.10.8 measuring element

part of the meter which produces an output proportional to the energy or other measured quantity

NOTE The term energy can refer to active energy (fundamental or net), apparent energy (fundamental, total or derived), fundamental reactive energy, non-active reactive energy or ampere squared energy in a single phase circuit or polyphase circuit unless a specific energy and circuit configuration is stated.

3.10.9 memory
element which stores digital information

3.10.10 non-volatile memory
memory which can retain information in the absence of power

3.10.11 display
device which displays the contents of a memory

3.10.12 register
electromechanical or electronic device comprising both memory and display which stores and displays information

NOTE A single display may be used with multiple electronic memories to form multiple registers.

3.10.13 current circuit
internal connections of the meter and part of the measuring element through which flows the current of the circuits to which the meter is connected

NOTE The current signal provided to the meter may be a voltage, in which case the current circuit is supplied with a voltage representing the current which the meter is measuring.

3.10.14 voltage circuit
internal connections of the meter, part of the measuring element, and in certain meters also the power supply for the meter, supplied with the voltage of the circuits to which the meter is connected

3.10.15 auxiliary supply
power supply for the meter if this supply is not obtained from the voltage circuit

3.10.16 auxiliary circuit
elements and connections of an auxiliary device within the meter case intended to be connected to an external device

NOTE Examples of elements include lamps and contacts. Examples of external devices include clocks, relays and impulse counters.

3.10.17 indoor meter
meter which can only be used with additional protection against environmental influences

3.10.18 outdoor meter
meter which can be used without additional protection in an exposed environment

3.10.19 base
back of the meter to which the measuring element, the terminals or the terminal block, and the cover are attached

NOTE For a flush-mounted meter, the meter base may include the sides of the case. Where the meter is built into an enclosure, the meter base may include the entire enclosure.

3.10.20 cover
enclosure on the front of the meter, made either wholly of transparent material or of opaque material provided with a window or windows through which the operation indicator, if fitted, and the display can be read

3.10.21 case
base and the cover together with any other component parts which together enclose the meter

3.10.22 terminal block
support made of insulating material on which all or some of the terminals of the meter are grouped together

3.10.23 terminal cover
cover for the meter terminals and, generally, the ends of the external wires or cables connected to the terminals

3.10.24 insulating encased meter of protective class II
meter with a case of insulating material in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions are provided, there being no provision for protective earthing or reliance upon installation conditions

NOTE Examples of safety precautions include double insulation or reinforced insulation.

3.11 output devices

3.11.1 test output
device which can be used for testing the meter

3.11.2 operation indicator
device which gives a visible signal that the meter is in operation

3.11.3 pulse
wave that departs from an initial level for a limited duration of time and ultimately returns to its original level

3.11.4 pulse output
device for initiating or transmitting electric pulses, representing finite quantities such as energy, normally transmitted from some form of electricity meter to a receiver unit

NOTE The term energy can refer to active energy (fundamental or net), apparent energy (fundamental, total or derived), fundamental reactive energy, non-active reactive energy or ampere squared energy in a single phase circuit or polyphase circuit unless a specific energy and circuit configuration is stated.

3.11.5 analogue output
device which produces signals which are analogue functions of the measurands

3.11.6 digital output
device which produces signals which are digital functions of the measurands

3.11.7 compliance voltage
value of the voltage that can be generated by the output current while conforming to the requirements of the accuracy specification for that output

NOTE This definition applies to current analogue output signals.

3.11.8 ripple content
peak-to-peak value of the fluctuating component of the output with steady state input conditions

NOTE This definition applies to analogue output signals.

3.11.9 response time

time from the instant of application of a specific change of the measurand until the output signal reaches and remains at its final steady value or within a specified band centred on this value

3.12 meter constant

value expressing the relation between the energy registered by the meter and the corresponding value of the test output

NOTE 1 If this value is a number of pulses, the constant should be either pulses per unit of energy (imp/kWh, imp/kVAh, imp/kvarh, etc.) or units of energy per pulse (Wh/imp, VAh/imp, varh/imp, etc.)

NOTE 2 The term energy can refer to active energy (fundamental or net), apparent energy (fundamental, total or derived), fundamental reactive energy, non-active reactive energy or ampere squared energy in a single phase circuit or polyphase circuit unless a specific energy and circuit configuration is stated.

3.13 reference current

3.13.1 basic current [2)]

current in accordance with which the relevant performance of a direct connected meter is fixed

NOTE The symbol for basic current is I_b.

3.13.2 rated current [2)]

current in accordance with which the relevant performance of a transformer operated meter is fixed

NOTE 1 The symbol for rated current is I_n.

NOTE 2 The current signal provided to the meter may be a voltage. In this case the rated current becomes the rated current (voltage) signal.

3.13.3 maximum current [2)]

highest value of current at which the meter purports to meet the accuracy requirements of this specification

NOTE The symbol for maximum current is I_{max}.

3.14 reference voltage [2)]

value or range of the voltage at which the meter purports to meet the accuracy requirements of this specification

NOTE 1 If a voltage range is specified, and a specific reference voltage is not stated, the reference voltage can be taken as the arithmetic mean of the range.

NOTE 2 The symbol for reference voltage is U_n.

3.15 reference frequency

value or range of the frequency at which the meter purports to meet the accuracy requirements of this specification

NOTE If a frequency range is specified, and a specific reference frequency is not stated, the reference frequency can be taken as the arithmetic mean of the range.

[2)] The terms "voltage" and "current" indicate r.m.s. values unless otherwise specified.

3.16 class index
number which gives the limits of the permissible percentage error, for all values of current between 0.1 I_b and I_{max}, or between 0.05 I_n and I_{max}, for unity phase influence function (and in the case of polyphase meters with balanced loads) when the meter is tested under reference conditions

NOTE 1 Reference conditions includes permitted tolerances on the reference values.

NOTE 2 Reference current can refer to basic current or rated current as appropriate.

3.17 phase influence function
function of the real or apparent phase angle between a measured voltage and a measured current

NOTE 1 Phase influence function expressed as a power factor refers to measurements of real and apparent powers and energies, while sin φ refers to reactive powers and energies.

NOTE 2 For d.c. measurements the requirements for a phase influence function of 1 need to be used.

3.18 influence quantities

3.18.1 influence quantity
any quantity, generally external to the meter, which might affect its working performance

NOTE Modified from IEC 60050:2001, IEV 301-08-09.

3.18.2 reference conditions
appropriate set of influence quantities and performance characteristics, with reference values, their tolerances and reference ranges, with respect to which the intrinsic error of the meter is specified

NOTE Modified from IEC 60050:2001, IEV 301-08-10.

3.18.3 variation of error due to the change in an influence quantity
difference between the percentage errors of the meter when only one influence quantity assumes successively two specified values, one of them being the reference value

3.18.4 distortion factor
ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the non-sinusoidal quantity

NOTE 1 The distortion factor is usually expressed as a percentage.

NOTE 2 The harmonic content is obtained by subtracting the fundamental term from a sinusoidal alternating quantity.

3.18.5 electromagnetic disturbance
conducted or radiated electromagnetic interferences which might affect the functional or metrological operation of the meter

3.18.6 reference temperature
ambient temperature specified for reference conditions

3.18.7 mean temperature coefficient
ratio of the variation of the percentage error to the change of temperature which produces this variation

3.18.8 rated operating conditions
set of specified measuring ranges for performance characteristics and specified operating ranges for influence quantities, within which the variations or operating errors of a meter are specified and determined

3.18.9 specified measuring range
set of values of a measured quantity for which the error of a meter is intended to lie within particular limits

3.18.10 specified operating range
range of values of a single influence quantity which forms a part of the rated operating conditions

3.18.11 limit range of operation
extreme conditions which an operating meter can withstand without damage and without degradation of its metrological characteristics when it is subsequently operated under its rated operating conditions

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

3.18.13 normal working position
position of the meter defined by the manufacturer for normal service

3.18.14 thermal stability
state when the change in error as a consequence of thermal effects during 20 minutes is less than 0.1 times the maximum permissible error for the measurement under consideration

3.19 type test
procedure according to which the series of tests is carried out on one meter or on a small number of meters of the same type having identical characteristics, selected by the manufacturer, to verify that the respective type of meter conforms to all the requirements of this specification for the relevant class of meters

NOTE A type test for safety is defined in BS EN 61010-1. The type test referred to above is for performance purposes only.

4 Standard electrical values

4.1 Standard reference voltages

The standard reference voltage shall be specified on or with the meter [see **12.1**e)].

NOTE 1 Standard reference voltages are given in Table 1. The exceptional values specified in Table 1 are not to be considered an exhaustive listing.

NOTE 2 The term meter can refer to a watt-hour meter, VA-hour meter, var-hour meter or ampere squared hour meter or a meter which measures multiple energies unless a specific meter is stated.

Table 1 **Standard reference voltages**

Meters	**Standard values** V	**Exceptional values** V
Meters for direct connection	120-230-277-400-480 (IEC 60038)	100-127-200-220-240-380-415
Meters for connection through voltage transformers	57.7-63.5-100-110-115-120-200-230 (BS EN 60044-2)	173-190-220

4.2 Standard reference currents

The standard reference current shall be specified on or with the meter [see **12.1**f)].

NOTE Standard reference currents are given in Table 2. The exceptional values specified in Table 2 are not to be considered an exhaustive listing.

Table 2 **Standard reference currents**

Meters	Standard values	Exceptional values
Meters for direct connection (basic current) I_b	5-10-15-20-30-40-50 Amp	80 Amp
Meters for connection through current transformers (rated current) I_n	1-2-5 Amp (BS EN 60044-1)	2.5 Amp
Meters for connection through current sensor (rated current) I_n	0.33 Vrms	

4.3 Maximum current

The maximum current shall be specified on or with the meter [see **12.1**f)]. The maximum current for direct connected meters shall be an integral multiple of the basic current (e.g. four times the basic current).

NOTE 1 The maximum current for transformer connected meters should be 1.2 I_n, 1.5 I_n or 2 I_n where I_n is the rated current. These values of maximum current are not to be considered an exhaustive listing.

NOTE 2 When the meter is operated from one or a number of current transformers, attention is drawn to the need to match the current range of the meter to that of the secondary current of the current transformers.

4.4 Standard reference frequencies

The reference frequency shall be specified either on the meter or in its accompanying documentation [see **13**c)].

NOTE Meters should use the standard reference frequencies of 50 Hz or 60 Hz where possible, although other reference frequencies, or reference frequency ranges, including d.c., may be specified.

5 Mechanical requirements

NOTE Meters should be designed and constructed in such a way as to avoid introducing any danger in normal use and under normal conditions, so as to ensure especially personal safety against electric shock, against the effects of excessive temperature and against the spread of fire. All parts which are subject to corrosion under normal working conditions should be protected effectively. Any protective coating should not be liable to damage by ordinary handling nor damage due to exposure to air, under normal working conditions.

5.1 Case

The meter shall have a case which ensures that the internal parts of the meter are accessible only by the use of a tool. If the meter has a seal, the internal parts of the meter shall only be accessible by breaking the seal or seals.

If the meter is fitted with a separate cover, the cover shall be removable only with the use of a tool.

The case shall be constructed and arranged so that any non-permanent deformation does not prevent the operation of the meter.

Meters intended to be connected to a supply mains where the voltage under reference conditions exceeds 250 V to earth, and whose case is wholly or partially made of metal, shall be provided with a protective conductor terminal.

5.2 Window

If the meter is fitted with a cover that is not transparent, one or more windows shall be provided for reading the display and observation of the operation indicator, if fitted. These windows shall be of transparent material that cannot be removed undamaged without the use of a tool. If the meter is provided with the facility to fit a seal, it shall not be possible to remove an undamaged window without breaking the seal or seals.

5.3 Terminals and terminal blocks

The terminal block used shall be suitable for the specified applied voltages to the meter under its intended measurement category as given in BS EN 61010-1, and for the maximum currents and the protective class of the meter.

The manner of fixing the conductors to the terminals shall ensure adequate and durable contact so as to minimize the risk of loosening or undue heating. Screw connections transmitting contact force and screw fixings that might be loosened and tightened several times during the life of the meter shall screw into a metal nut.

NOTE 1 Terminals may be grouped in one or a number of terminal blocks having adequate insulating properties and mechanical strength.

All parts of each terminal shall be constructed so as to minimize the risk of corrosion resulting from contact with any other metal part.

Electrical connections shall be such that contact pressure is not transmitted through insulating material.

Current circuits intended for connection through current transformers shall be considered to be at earth potential and galvanically isolated from the voltage terminals unless specified otherwise.

NOTE 2 For current circuits of direct connected meters, the voltage is considered to be the same as for the related voltage circuit.

Terminals with different potentials which are grouped close together shall be protected against accidental short-circuiting.

NOTE 3 Protection may be obtained by insulating barriers or by separation. Terminals of one current circuit are considered to be at the same potential.

If the terminal cover is made of metal, the terminals, the conductor fixing screws, and the external and internal conductors shall be insulated from the terminal cover in accordance with BS EN 61010-1 and shall not be able to come into contact with the terminal cover while it is being fitted or removed.

5.4 Terminal covers

The terminals of a meter, if grouped in a terminal block and if not protected by any other means, shall have a cover which can only be removed by the use of a tool. If the meter is provided with the facility to fit a seal, the terminal cover shall be separate from the meter cover and shall be separately sealable. The terminal cover, if provided, shall enclose the actual terminals, the conductor fixing screws and a suitable length of the external conductors and their insulation.

NOTE Where the meter is panel mounted, or designed for mounting within a panel, and there exists no access to the terminals from outside the panel, the terminal cover may be omitted.

5.5 Insulating encased meter of protective class II

If small metal parts are accessible to the standard test finger as specified in BS EN 60529 from outside the case, then they shall be additionally isolated from live parts by supplementary insulation.

NOTE 1 The insulating properties of lacquer, enamel, ordinary paper, cotton, oxide film on metal parts, adhesive film and sealing compound, or similar unsure materials are not sufficient for supplementary insulation.

NOTE 2 For the terminal block and terminal cover of such a meter, reinforced insulation is sufficient.

5.6 Protection against shock

When tested in accordance with **A.1**, meters shall conform to BS EN 61010-1 for mechanical resistance to shock and impact.

5.7 Protection against vibration

When tested in accordance with **A.2**, the meter shall show no damage or change in information and shall operate correctly in accordance with this specification.

5.8 Protection against penetration of dust and water

When tested in accordance with **A.3** and **A.4**, indoor meters shall conform to IP51, but without suction in the meter, and outdoor meters shall conform to IP65. The ingress of dust shall be only in a quantity not impairing the operation of the meter and its dielectric strength (insulating strength). Any ingress of water shall be only in a quantity not impairing the operation of the meter and its dielectric strength (insulating strength).

Where the meter is designed for mounting within a panel or enclosure, this requirement shall apply to a meter so mounted. Installation instructions shall be included in the documentation accompanying the meter [see **13**j)].

NOTE Examples of such meters are those designed for mounting on a DIN rail.

5.9 Display of measured values

NOTE 1 The measured values can be shown either by an electromechanical register or an electronic display.

Where an electronic display is used, any corresponding non-volatile memory shall have a retention time of at least four months.

NOTE 2 A longer retention time of the non-volatile memory should be the subject of a purchase contract.

If a single display is used to present multiple values, then means of identifying which values are being presented shall be provided.

The principal unit for the measured values shall be indicated near to the displayed value. If the meter is capable of displaying multiple measured values, the respective principal unit for each measured value shall be clearly identifiable and correctly attributable to its corresponding display. Standard engineering units shall be used at all times.

For registers which indicate a decimal fraction or multiple of a unit without displaying a suitably positioned decimal point, the necessary scale factor shall be clearly indicated.

NOTE 3 Suitable methods for indicating scale factors include:

- *for a fractional scale factor, a coloured or clearly marked display, or a legend such as "kWh/10" indicating the units of the display;*
- *for a multiple scale factor, a legend such as "10 kWh" indicating the units of the display.*

The register shall be able to record and display, starting from zero, for a minimum of 1 500 h, the energy corresponding to the maximum current at the reference voltage and a phase influence function of unity.

NOTE 4 When the meter is not energized, electronic displays need not be legible.

NOTE 5 The term energy can refer to active energy (fundamental or net), apparent energy (fundamental, total or derived), fundamental reactive energy, non-active reactive energy, ampere squared energy in a single phase circuit or ampere squared energy in a polyphase circuit unless a specific energy and circuit configuration is stated.

5.10 Output device

The meter shall have a test output device accessible from in front of the meter and capable of being monitored with suitable testing equipment.

The operation indicator, if fitted, shall be visible from in front of the meter.

6 Climatic conditions

6.1 Rated operating conditions for temperature

The minimum rated operating conditions and minimum storage and transport conditions for temperature shall be as shown in Table 3.

NOTE The values given in Table 3 are based on BS EN 60721-3-3:1995, Table 1, with the exception of m) condensation and p) formation of ice.

When tested in accordance with **B.1** and **B.2**, on visual inspection the meter shall show no signs of damage, the legibility of the markings shall not be altered and the function of the meter shall not be impaired.

Table 3 **Rated operating conditions for temperature**

Operating range	**Indoor meter** °C	**Outdoor meter** °C
Specified operating range	–10 to +45	–25 to +55
Limit range of operation	–20 to +55	–25 to +60
Limit range for storage and transport	–25 to +70	–25 to +70

NOTE 1 For special applications, other temperature values can be used according to a purchaser contract.

NOTE 2 Storage and transport of the meter should only be at the extremes of this temperature range for a maximum period of 6 h.

6.2 Relative humidity

The minimum rated operating conditions and minimum storage and transport conditions for relative humidity shall be as shown in Table 4.

When tested in accordance with **B.3**, on visual inspection the meter shall show no signs of damage, the legibility of the markings shall not be altered and the function of the meter shall not be impaired.

NOTE The limits of relative humidity as a function of ambient air temperature are shown in Figure 1.

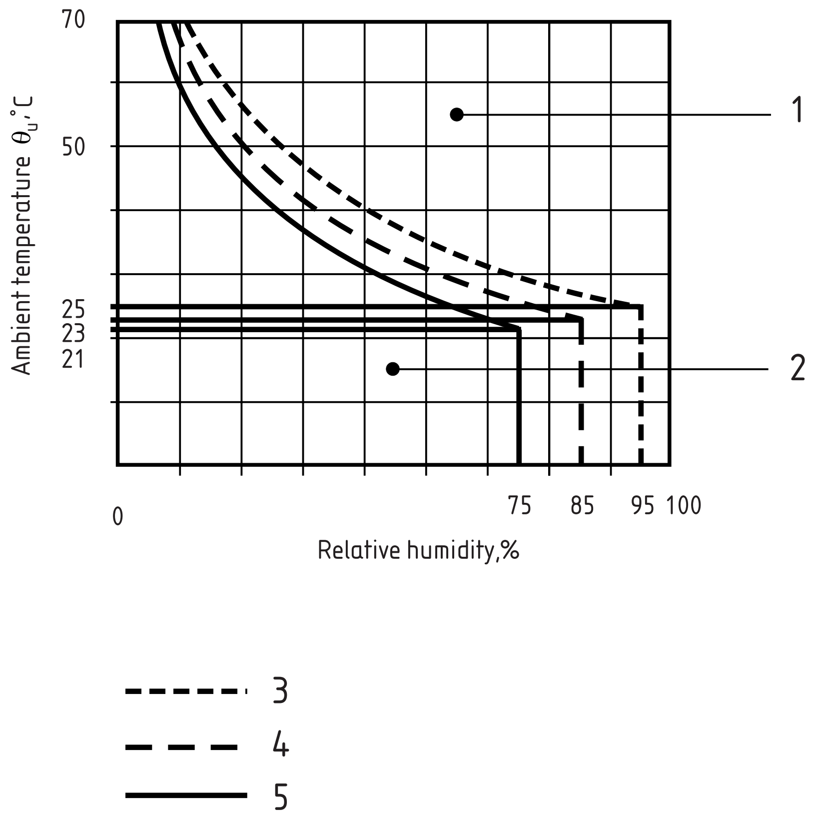
Table 4 **Relative humidity**

Timescale	**Relative humidity** %
Annual mean	≤ 75
For thirty days, these days being spread in a natural manner throughout one year	95
Occasionally on other days	85

6.3 Protection against solar radiation for meters intended for outdoor use

When meters intended for outdoor use are tested in accordance with **B.4** and inspected, the markings shall be legible and the function of the meter shall not be impaired.

Figure 1 **Relationship between ambient air temperature and relative humidity**



Key

1 Climatic conditions that do not occur in practice

2 Climatic conditions that do occur in practice

3 Limits for each of thirty days spread in a natural manner over one year

4 Limits occasionally reached on other days

5 Annual mean

7 Electrical requirements

7.1 Power consumption: voltage circuits

When tested in accordance with **C.2**, the total consumption at reference voltage, reference temperature and reference frequency of all the voltage circuits, including any auxiliary supply necessary for the operation of the meter, shall be no greater than the values given by the following formulae:

$P = 2m$

$S = 10m$

where *m* is the number of measuring elements, *P* is power in watts and *S* is the apparent power in VA.

NOTE The above figures are mean values. Switching power supplies with peak values in excess of these are permitted, but attention should be paid to the rating of associated voltage transformers.

7.2 Power consumption: current circuits

When tested in accordance with **C.2**, the apparent power taken by each current circuit of a direct connected meter at basic current, reference frequency and reference temperature shall be no greater than 2.5 VA.

The apparent power taken by each current circuit of a meter connected through a current transformer shall be no greater than 2.5 VA at a current value that equals the rated secondary current of the corresponding transformer at the reference temperature and reference frequency of the meter.

NOTE The rated secondary current is the value of the secondary current of a current transformer on which the performance of the transformer is based. Standard values of maximum secondary current are 120%, 150% and 200% of the rated secondary current.

7.3 Influence of voltage

7.3.1 Voltage range

The meter shall be tested in accordance with **E.2**. Voltage ranges shall be in accordance with Table 5.

Table 5 **Voltage range**

Operating range	Measurement (no auxiliary supply fitted)	Measurement (auxiliary supply fitted)	Auxiliary supply
Specified operating range	$0.9u_1$ to $1.1u_2$	$0.8u_1$ to $1.2u_2$	u_{a1} to u_{a2}
Limit range of operation	0 to $1.15u_2$	0 to $1.2u_2$	0 to $1.05u_{a2}$

- If the reference voltage is specified as a range, then u_1 and u_2 shall be the lower and upper limits respectively of that range.
- If the reference voltage is specified as a single value, then u_1 and u_2 shall both be equal to that value.
- If the auxiliary voltage is specified as a range, then u_{a1} and u_{a2} shall be the lower and upper limits respectively of that range and the difference between them shall not be less than 10% of their sum.
- If the auxiliary voltage is specified as a single value u_a, then the following expressions shall be satisfied: $u_{a1} = 0.9u_a$ and $u_{a2} = 1.1u_a$.

The errors in power and energy measurement due to voltage variation shall be within the limits specified in Table 10.

7.3.2 Voltage dips and short interruptions

When tested in accordance with **C.3**, there shall be no change in the register of more than *x* and the test output shall not produce a signal equivalent to more than *x* where

$$x = NmU_nI_{max} \times 10^{-6}$$

where

N is the accuracy class of the meter;
m is the number of measuring elements;
U_n is the reference voltage in volts;
I_{max} is the maximum current in amperes.

NOTE 1 x is measured in kWh, kvarh or kVAh as applicable.

NOTE 2 For transformer-operated meters, equivalent values should be used taking into account the transformation ratios.

7.4 Influence of short-time over-currents

Short-time overcurrents shall not damage the meter. When tested in accordance with **C.4**a), direct connection meters shall perform correctly when back to their initial working conditions and the variation of error shall be no greater than the values shown in Table 6.

When tested in accordance with **C.4**b), meters for connection through a current transformer shall perform correctly when back to their initial working conditions and the variation of error shall be no greater than the values shown in Table 6.

Table 6 **Variation due to short term over-currents**

Meter	**Value of current**	**Phase influence function**		**Limits of variation in percentage error for a meter of accuracy class N**
		Power factor	**sin φ inductive or capacitive**	
Meter for direct connection	I_b	1	1	1 + (0.5 × N)
Meter for connection through current transformers	I_n	1	1	0.5 × N

7.5 Influence of self-heating

When tested in accordance with **C.5**, the variation of error due to self-heating shall be no greater than the values given in Table 7.

Table 7 **Variations due to self-heating**

Value of current	**Phase influence function**		**Limits of variation in percentage error for a meter of accuracy class N**
	Power factor	**sin φ inductive or capacitive**	
I_{max}	1	1	0.5 + (0.25 × N)
	0.5 inductive	0.5	0.5 + (0.5 × N)

7.6 Influence of heating

When tested in accordance with **C.6**, the temperature rise at any point on the external surface of the meter shall not exceed 25 K at an ambient temperature of 40 °C.

Upon inspection the meter shall show no signs of damage.

7.7 Insulation

When tested in accordance with the impulse voltage test in **F.4.3** and the a.c. voltage test in **F.4.4**, under the test conditions given in **F.4.2**, the meter shall conform to the impulse voltage and a.c. voltage test requirements of BS EN 61010-1 and BS EN 61010-2-030.

7.8 Immunity to earth fault

When tested in accordance with **C.9**, the meter shall show no damage and shall operate correctly.

The change in error when the meter is back at nominal working temperature shall be no greater than 0.5 + (0.25 × N) when tested at reference conditions, nominal current and unity phase influence function.

7.9 Analogue outputs

7.9.1 General

When tested in accordance with **C.7**, the overall accuracy of each analogue output representing a measured parameter shall be within the accuracy limits specified for the measurement of that parameter in Clause **9** unless stated otherwise.

For a meter fitted with analogue outputs, the requirements specified in **7.9.5** shall apply.

NOTE 1 The current analogue output signal should be 4 mA to 20 mA but other possible current output signals include: 0 mA to 20 mA; 0 mA to 1 mA; 0 mA to 10 mA; –1 mA to 0 mA to 1 mA; –10 mA to 0 mA to 10mA.

NOTE 2 There is no preferred voltage output signal. Possible output signals include: 0 V to 1 V; 0 V to 10 V; –1 V to 0 V to 1 V; –10 V to 0 V to 10 V.

7.9.2 Compliance voltage

Current output signals shall have a compliance voltage of at least 10 V. The actual compliance voltage shall be specified in the accompanying documentation [see **13**d)].

When tested in accordance with the compliance voltage tests of **C.7.4**, the error in the analogue output shall not exceed (2 × N)% for a meter with an analogue output of accuracy class N.

7.9.3 Analogue output ripple content

When tested in accordance with **C.7.2**, the maximum ripple content in the output signal for an output of accuracy class N shall not exceed (2 × N)% of the maximum specified output signal.

7.9.4 Analogue output response time

The response time shall be measured in accordance with **C.7.5**. The response time, for both increasing and decreasing inputs if different, shall be specified in the accompanying documentation [see **13**e)].

7.9.5 Limiting value of the analogue output signal

The output signal shall be limited to a maximum of twice the nominal maximum output signal. For bipolar outputs, this shall apply in both directions.

When tested in accordance with **C.7.3**, when the measurand is not between the lower and upper values represented by the maximum and minimum output signals, the meter shall not, under any conditions of operation except loss of auxiliary power, produce an output having a value between its maximum and minimum output signals.

7.10 Digital outputs

7.10.1 General

When tested in accordance with **C.8**, the overall accuracy of each digital output representing a measured parameter shall be within the limits specified in Clause **9** for the measurement of that parameter unless stated otherwise.

7.10.2 Digital output response time

The response time shall be measured in accordance with **C.8.2**.
The response time of the digital output, for both increasing and decreasing inputs if different, shall be specified in the accompanying documentation [see **13**f)].

*NOTE The response time for a digital output is the maximum delay time from a 0% to 100% input step signal to an output signal step from 0% to 90%. If any digital averaging or filtering is used, this should be specified in the accompanying documentation [see **13**g)].*

8 Electromagnetic compatibility (EMC)

8.1 Immunity to electromagnetic disturbance

8.1.1 General

The meter shall be designed in such a way that conducted or radiated electromagnetic disturbance as well as electrostatic discharge do not damage the meter nor substantially influence the result of measurement.

NOTE 1 The electromagnetic disturbances to be considered are:

- *electrostatic discharges;*
- *electromagnetic RF fields;*
- *fast transient burst;*
- *conducted voltages induced by radio-frequency fields;*
- *surges;*
- *oscillatory waves;*
- *radio interference.*

When tested in accordance with **D.2** to **D.8**, the meter shall show no visible signs of damage upon inspection and shall operate correctly.

*NOTE 2 See **8.1.2** to **8.1.7** and **8.2** for detailed performance requirements.*

8.1.2 Immunity to electrostatic discharges

When tested in accordance with **D.2**, the meter shall show no damage or change of information and shall stay within the accuracy requirements specified in Clause **9** once the test is complete. Any temporary degradation or loss of function or performance during the test which ceases after the test shall be discounted.

The application of the electrostatic discharge shall not produce a change in the register of more than *x* and the test output shall not produce a signal equivalent to more than *x*, where *x* is as specified in **7.3.2**.

8.1.3 Immunity to electromagnetic radio-frequency (RF) fields

The meter shall be tested in accordance with **D.3**.

When tested without any current in the current circuits, the application of the RF field shall not produce a change in the register of more than *x* and the test output shall not produce a signal equivalent to more than *x*, where *x* is as specified in **7.3.2**. Any temporary degradation or loss of function or performance during the test which ceases after the test shall be discounted.

When tested with basic current I_b, respectively the rated current I_n, and a phase influence function equal to 1, the variation of error shall be within the limits given in Table 10.

8.1.4 Immunity to fast transient burst

The meter shall be tested in accordance with **D.4**.

When tested under operating conditions with basic current I_b, respectively the rated current I_n, and phase influence function equal to 1:

- for energy parameters, registration during this test shall not vary from a test under the same load conditions without application of the transients by more than (4 × N)% for a meter of class N;
- for other parameters, application of the transients shall not affect the reading by more than (4 × N)% for a meter of class N.

When tested without any current in the current circuits, the application of the burst fire test voltage shall not produce a change in the register of more than four times *x* and the test output shall not produce a signal equivalent to more than four times *x*, where *x* is as specified in **7.3.2**. Any temporary degradation or loss of function or performance during the test which ceases after the test shall be discounted (BS EN 61000-4-4, performance category B).

8.1.5 Immunity to conducted disturbances, induced by RF fields

When tested in accordance with **D.5**, during the test, the behaviour of the equipment shall not be perturbed and the variation of the error shall be within the limit given by the equation:

Additional Error: ±2 N%
where N is the accuracy class of the meter.

8.1.6 Surge immunity

When tested in accordance with **D.6**, the test shall not produce a change in the register of more than *x* and the test output shall not produce a signal equivalent to more than *x*, where *x* is as specified in **7.3.2**.

8.1.7 Damped oscillatory waves immunity

When tested in accordance with **D.7**, the behaviour of the equipment shall not be perturbed and the variation of the error shall be within the limit given by the equation:

Additional Error: ±2 N%
where N is the accuracy class of the meter.

8.2 Radio interference suppression

When tested in accordance with **D.8**, the test results shall conform to the requirements given in BS EN 55022.

9 Accuracy requirements

9.1 Accuracy requirements for power and energy readings

NOTE 1 Power can refer to active power (fundamental or net), apparent power (fundamental, total or derived), reactive power (fundamental or non-active), ampere squared (A^2) power (single phase), polyphase ampere squared (A^2) power, polyphase active power, polyphase apparent power, fundamental polyphase reactive power or non-active reactive polyphase power unless a specific power is referred to.

NOTE 2 The term energy can refer to active energy (fundamental or net), apparent energy (fundamental, total or derived), fundamental reactive energy, non-active reactive energy or ampere squared energy in a single phase circuit or polyphase circuit unless a specific energy and circuit configuration is stated.

9.1.1 Error calculation

Class indices or potential errors computed according to other definitions of percentage error (such as defined in BS EN 60688) shall only be specified alongside figures computed in accordance with this standard if clear differentiation is made between the two figures.

NOTE 1 The preferred method of differentiation is to state that the error is either:

"… as a percentage of full scale" or "… as a percentage of reading".

An alternative method of differentiation is to state that the error is either:

"… according to BS EN 60688" or "… according to [standard reference]".

NOTE 2 Since the actual value being measured cannot be determined, it is approximated by a value with a stated uncertainty that can be traced to standards agreed upon between manufacturer and user or to national standards.

9.1.2 Percentage error in energy

The percentage error in energy, P_E, shall be calculated using the following formula:

$$P_E = \frac{E_R - E_A}{E_A}$$

where E_R is the energy registered by the meter and E_A is the actual energy.

9.1.3 Percentage error of instantaneous value

The percentage error of the instantaneous value measured by the meter, $P_{I,}$ shall be calculated using the following formula:

$$P_I = \frac{V_R - V_A}{V_A}$$

where V_R is the value registered by the meter and V_A is the actual value.

9.1.4 Limits of error due to variation of the current

When the meter is under reference conditions given in **E.1**, the percentage errors for a meter of accuracy class N in measuring power and energy shall not exceed the limits given in Table 8 and Table 9.

NOTE Phase influence function expressed as a power factor refers to measurements of real and apparent powers and energies, while sin φ refers to reactive powers and energies.

Table 8 **Percentage error limits for power and energy parameters for single phase meters and polyphase meters with balanced load**

Specified measuring range		Phase influence function		Percentage error limits for a meter of accuracy class N
Current for direct connected meters	**Current for transformer operated meters**	**Power factor**	**sin φ inductive or capacitive**	
$0.05\ I_b \le I < 0.1\ I_b$	$0.02\ I_n \le I < 0.05\ I_n$	1	1	±(1.5 × N)
$0.1\ I_b \le I \le I_{max}$	$0.05\ I_n \le I \le I_{max}$	1	1	±(1.0 × N)
$0.1\ I_b \le I < 0.2\ I_b$	$0.05\ I_n \le I < 0.1\ I_n$	0.5 inductive	0.5	±(1.5 × N)
		0.8 capacitive		±(1.5 × N)
$0.2\ I_b \le I \le I_{max}$	$0.1\ I_n \le I \le I_{max}$	0.5 inductive	0.5	±(1.0 × N)
		0.8 capacitive		±(1.0 × N)
$0.2\ I_b \le I$ „ I_b	$0.1\ I_n \le I \le I_n$	0.25 inductive[A)]	0.25[A)]	±(3.5 × N)
		0.5 capacitive[A)]		±(2.5 × N)

A) When specifically requested by the user.

Table 9 **Percentage error limits for power and energy parameters for polyphase meters carrying a single phase load, but with balanced polyphase voltages applied to voltage circuits**

Specified measuring range		Phase influence function		Percentage error limits for a meter of accuracy class N
Current for direct connected meters	**Current for transformer operated meters**	**Power factor**	**sin φ inductive or capacitive**	
$0.1\ I_b \le I \le I_{max}$	$0.05\ I_n \le I \le I_{max}$	1	1	±(2.0 × N)
$0.2\ I_b \le I \le I_{max}$	$0.1\ I_n \le I \le I_{max}$	0.5 inductive	0.5	±(2.0 × N)

The difference between the percentage error when the meter is carrying a single-phase load and a balanced polyphase load at basic current I_b and unity phase influence function for directly connected meters, respectively at rated current I_n and unity phase influence function for transformer operated meters, shall not exceed (1.5 × N)%.

When testing for conformity to Table 9, the test current shall be applied to each element in sequence.

Certain test results might fall outside the limits indicated in Table 8 and Table 9, owing to uncertainties of measurements and other parameters capable of influencing the measurements, but if by one displacement of the zero line parallel to itself by no more than 0.5 × N where N is the class of the meter, all the test results are brought within the limits indicated in Table 8 and Table 9, the meter type shall be considered acceptable.

9.1.5 Limits of error due to other influence quantities (voltage variation, frequency variation, waveform, phase sequence, voltage unbalance)

9.1.5.1 General

When tested in accordance with **E.2**, the limit of variation of error due to the change in an influence quantity with respect to reference conditions, as given in **E.1**, shall be no greater than the limits for the relevant accuracy class given in Table 10.

9.1.5.2 Voltage variation

NOTE If the meter requires an auxiliary supply, the voltage variation applies to both the auxiliary supply and the voltage measurement circuits, both jointly and separately.

If the reference voltage and/or auxiliary voltage is specified as a range, then the positive and negative percentage variations shall respectively be applied to the upper and lower limits of the range. However, the variation applied to the auxiliary supply shall be modified if necessary to ensure that it remains within the specified operating range.

9.1.5.3 Voltage unbalance

For polyphase meters with an auxiliary supply, the meter shall measure and register within the limits of variation in percentage error shown in Table 10 if one or two phases of the three phase network are interrupted. For polyphase meters powered from the voltage measurement inputs, and where the inputs providing power to the meter are specified, the meter shall measure and register within the limits of variation in percentage error shown in Table 10 if any of the other phase or phases of the three phase network are interrupted.

9.1.5.4 Magnetic induction

When tested in accordance with **E.2.4** and **E.2.5**, the most unfavourable conditions of phase and direction shall cause no variation in the percentage error of the meter exceeding the value shown in Table 10.

9.1.5.5 Harmonics and sub-harmonics in the current circuit

When tested in accordance with **E.2.3**, the distortion factor of the voltage shall be no more than 1%.

NOTE Testing for the effects of d.c. and even harmonics in the current circuit is not required.

Table 10 **Influence quantities**

Influence quantity	Specified measuring range		Phase influence function		Percentage error limits for a meter of accuracy class N
	Value of current for direct connected meters	Value of current for transformer operated meters	Power factor	sin φ inductive or capacitive	
Voltage variation ±10% A)	$0.05\ I_b \le I \le I_{max}$	$0.02\ I_n \le I \le I_{max}$	1	1	±(0.7 × N)
	$0.1\ I_b \le I \le I_{max}$	$0.05\ I_n \le I \le I_{max}$	0.5 inductive	0.5	±(1.0 × N)
Voltage variation ±20% (only for meters with an auxiliary supply) A)	$0.05\ I_b \le I \le I_{max}$	$0.02\ I_n \le I \le I_{max}$	1	1	±(1.5 × N)
	$0.1\ I_b \le I \le I_{max}$	$0.05\ I_n \le I \le I_{max}$	0.5 inductive	0.5	±(2.0 × N)
Frequency variation	$0.05\ I_b \le I \le I_{max}$	$0.02\ I_n \le I \le I_{max}$	1	1	±(0.5 × N)
Specified range or ±2% nominal A) B)	$0.1\ I_b \le I \le I_{max}$	$0.05\ I_n \le I \le I_{max}$	0.5 inductive	0.5	±(1.0 × N)
Reverse phase sequence B)	$0.1\ I_b$	$0.1\ I_n$	1	1	±(1.0 × N)
Voltage unbalance B)	I_b	I_n	1	1	±(2.0 × N)
Harmonic components in the current and voltage circuits	$0.5\ I_{max}$	$0.5\ I_{max}$	1	—	±(1.0 × N)
Odd harmonics in the current circuit B) C)	$0.5\ I_b$	$0.5\ I_n$	1	1	±(3.0 × N)
Sub-harmonics in the current circuit B) C)	$0.5\ I_b$	$0.5\ I_n$	1	1	±(3.0 × N)
Continuous magnetic induction of external origin	I_b	I_n	1	1	±(2.0 × N)
Magnetic induction of external origin 0.5 mT D)	I_b	I_n	1	1	±(2.0 × N)
Electromagnetic RF fields E)	I_b	I_n	1	1	±(2.0 × N)
Operation of accessories F)	$0.05\ _{Ib}$	$0.05\ _{In}$	1	1	±(0.5 × N)

A) The recommended test point for voltage variation and frequency variation is I_b, respectively I_n.

B) This test does not apply to meters when measuring d.c.

C) The test conditions are specified in **E.2**.

D) For an a.c. meter, a magnetic induction of external origin of 0.5 mT is produced by a current of the same frequency as that of the voltage applied to the meter. For a d.c. meter, a magnetic induction of external origin of 0.5 mT is produced by a current at line frequency.

E) The test conditions are specified in **D.3**.

F) Such an accessory, when enclosed in the meter case, is energized intermittently.

9.2 Accuracy requirements for parameters other than power and energy readings

9.2.1 General

When the meter is under reference conditions given in **E.1**, the errors or percentage errors for a meter of accuracy class N in measuring a parameter other than power or energy shall not exceed the limits given in **9.2.2** to **9.2.6**. The additional percentage error due to the change in influence quantities with respect to reference conditions, as given in **E.1**, shall not exceed the limits in Table 10.

9.2.2 Phase influence function parameters

NOTE 1 Phase influence function parameters are ratios of two power parameters. The error limit for the measurement of a phase influence function parameter for a meter of accuracy class N is given by the error limits of the powers whose ratio is that phase influence function.

The measurement of a phase influence function shall be considered to be within error limits if the true value of one of the related parameters, when scaled by the phase influence function, gives a value for the other related parameter which is within the error limits specified for that parameter, under that test condition, in Table 10.

NOTE 2 Phase influence function parameters include the power factor, cos φ, and sin φ.

NOTE 3 When testing for conformity, the test points selected should be those at which power and energy tests are normally carried out. Test currents applied should be I_{max} and 0.05 I_b, respectively 0.02 I_n.

9.2.3 Current

The measurement of a current shall be considered to be within error limits if the error as defined in **9.1.3** is less than (1 × N)%, where N is the accuracy class of the meter. The specified current operating range shall be 0.05 I_b, respectively 0.02 I_n, to I_{max}.

9.2.4 Voltage

The measurement of a voltage shall be considered to be within error limits if the error as defined in **9.1.3** is less than (1 × N)%, where N is the accuracy class of the meter. The specified voltage operating range shall be 0.5 U_n to 1.2 U_n.

9.2.5 Frequency

The measurement of frequency shall be considered to be within error limits if the error as specified in **9.1.3** is less than (1 × N)%, where N is the accuracy class of the meter. The range of measurement shall be the specified frequency range of the meter or, if only a single reference frequency is given, from 0.98 to 1.02 times that frequency. The range of operation shall be:

- if frequency is determined from a voltage, from 0.5 U_n to 1.2 U_n;
- if frequency is determined from a current, from 0.05 I_b, respectively 0.02 I_n, to I_{max}.

9.2.6 Other parameters

The measurement of a parameter shall be considered to be within error limits if the error as defined in **9.1.3** is less than (1 × N)%. The test current range shall be 0.05 I_b, respectively 0.02 I_n to I_{max}, and the test voltage range shall be from 0.5 U_n to 1.2 U_n.

9.2.7 Limits of error due to ambient temperature variation

The mean temperature coefficient for power and energy measurements shall be no greater than the limits given in Table 11. For other parameters, the mean temperature coefficient shall be no greater than (0.05 × N)% for a meter of accuracy class N.

Table 11 **Temperature coefficient for power and energy**

Value of current for direct connected meters	Value of current for transformer operated meters	Phase influence function		Mean temperature coefficient for a meter of accuracy class N
		Power factor	sin φ inductive or capacitive	%/K
$0.1\ I_b \leq I \leq I_{max}$	$0.05\ I_n \leq I \leq I_{max}$	1	1	0.05 × N
$0.2\ I_b \leq I \leq I_{max}$	$0.1\ I_n \leq I \leq I_{max}$	0.5 inductive	0.5	0.075 × N

The determination of the mean temperature coefficient for a given temperature shall be made over a 20 K temperature range, 10 K above and 10 K below that temperature, but in no case shall the temperature be outside the specified operating temperature range.

9.2.8 Starting and running with no load

9.2.8.1 General

For the tests of **9.2.8.2**, **9.2.8.3** and **9.2.8.4**, the conditions and the values of the influence quantities shall be as stated in **E.1** unless otherwise specified.

9.2.8.2 Initial start-up of the meter

If the meter requires an auxiliary supply voltage for operation, the meter shall be operational within 5 s after the rated voltage is applied to the auxiliary supply terminals.

For meters powered from the voltage measurement inputs, the meter shall be operational within 5 s after the rated voltage is applied to the meter terminals.

9.2.8.3 Running with no load

When tested in accordance with **E.3**, the test output of the meter shall produce no more than one pulse.

9.2.8.4 Starting

When tested in accordance with **E.4**, the meter shall start and continue to register at the current shown in Table 12.

Table 12 **Starting current**

Meters	Phase influence function		Starting current for a meter of class N
	Power factor	sin φ	
Meters for direct connection	1	1	$0.003\ I_b + (0.001\ I_b \times N)$
Meters for connection through current transformers	1	1	$0.001\ I_n + (0.001\ I_n \times N)$

9.2.9 Meter constant

The relation between the test output and the indication of energy in the display shall conform to the meter constant (see **E.5**).

The manufacturer shall state in the accompanying documentation the necessary number of pulses to ensure a measuring accuracy of at least one tenth of the class of the meter at the different test points [see **13**h)].

NOTE Output devices generally do not produce homogeneous pulse sequences.

9.2.10 Measurement technique

9.2.10.1 General

As some measurement techniques give misleading results under systematic variations of supply and load, the manufacturer shall indicate in the accompanying documentation which of the following categories most closely describes the equipment [see **13**i)].

9.2.10.2 Continuity of measurement: continuous measurement

Meters with a continuous measurement technique shall measure the input voltage and current signals continuously without any interruption.

9.2.10.3 Continuity of measurement: intermittent measurement

Meters with an intermittent measurement technique shall take a measurement or measurements and then presume a stable load until repeating the measurement cycle.

A meter shall be considered to use "intermittent measurement" if the measurement element is prevented from measurement (for a minimum of one cycle) by other requirements or functions of the meter.

9.2.10.4 Measurement of polyphase signals

9.2.10.4.1 Parallel measurement

The measurement technique used shall be such that each and every cycle of both current and voltage is measured, thus ensuring that no single event is missed.

For a polyphase meter, each and every cycle of both the current and the voltage of all the phases shall be measured.

9.2.10.4.2 Serial (or sequential) measurement

The measurement technique used is such that the meter will not necessarily measure each and every cycle of all phases.

A meter shall be considered to use "serial measurement" if the measurement element is switched to measure each phase in sequence in such a way that all individual cycles are not measured.

9.2.10.5 Testing measurement technique

When tested in accordance with **E.6**, the meter shall be considered to be:

- a single phase meter: using continuous measurement technique if the error in measurement is less than 5 N%.
- a polyphase meter: using parallel continuous measurement technique if the error in measurement is less than 5 N%.

10 Safety requirements

10.1 General safety requirements

Meters shall conform to the safety requirements specified in BS EN 61010-1 and BS EN 61010-2-030 except as follows:

a) the meter need not be marked with its maximum rated power or its maximum rated input current (see BS EN 61010-1:2010, **5.1.3**);

b) secondary meters are considered to be operating in measurement category III unless installation circumstances demand otherwise (see BS EN 61010-2-030:2010, Annex AA);

c) meters are not required to be provided with any means of disconnection (see BS EN 61010:2010, **6.11**).

When tested in accordance with **F.2** and **F.3**, meters shall conform to BS EN 61010-1 for mechanical resistance to shock and impact, and resistance to heat and fire.

10.2 Protective conductor terminal

The protective conductor terminal, if any, shall be sized to accommodate main current conductors.

After installation, it shall not be possible to loosen the protective conductor terminal without the use of a tool.

NOTE The protective conductor terminal should, if possible, form part of the meter base and should preferably be located adjacent to the terminal block.

11 Tests and test conditions

11.1 Test conditions

All meters shall be tested under reference conditions as specified in Table 13 unless otherwise stated.

11.2 Type testing

Type testing shall be carried out on the meter.

NOTE 1 A recommended test sequence is given in Annex G.

NOTE 2 In the case of modifications to the meter made after the type test and affecting only part of the meter, it is sufficient to perform limited tests on the characteristics that might be affected by the modifications.

Table 13 **Reference conditions**

Influence quantity	Reference value	Permissible tolerances for meters of class N
Ambient temperature	Reference temperature or, in its absence, 23 °C	±2 °C
Voltage	Reference voltage	±1.0 %
Frequency [A)]	Reference frequency	±[0.1 + (0.2 × N)]%
Waveform a.c. metering	Sinusoidal voltages and currents	Distortion factor less than 1 + (1 × N)%
Waveform d.c. metering	Pure d.c. voltages and currents	Ripple less than N%
Magnetic induction of external origin	Magnetic induction equal to zero	Induction value which causes a variation of error not greater than: ±[0.1 + (0.1 × N)]%. Induction value shall be less than 0.05 mT [B) C)]

A) A.C. metering only.

B) The test is as follows.

- For a single phase or d.c. meter, determining the errors first with the meter normally connected to a supply at the reference frequency and then after inverting the connections to the current circuit as well as the voltage circuit. Half of the difference between the two errors is the value of the variation of error. Because of the unknown phase of the external field, the test should be made at 0.1 I_b, respectively 0.05 I_n, at unity phase influence function and 0.2 I_b respectively 0.1 I_n, at 0.5 phase influence function.
- For a three phase a.c. meter, making three measurements at 0.1 I_b, respectively 0.05 I_n, at unity phase influence function, after each of which the connections to the current circuits and to the voltage circuits are changed over 120° while the phase sequence is not altered. The greatest difference between each of the errors so determined and their average value is the value of the variation of error.

C) For an a.c. meter, a magnetic induction of external origin is at the reference frequency. For a d.c. meter, a magnetic induction of external origin is at line frequency.

12 Marking

12.1 Name-plates

Meters shall be clearly, indelibly, distinctly and legibly marked, internally or externally, with the information given in a) to k). If the marking is internal it shall be legible from the outside of the meter. Meters shall either be marked with the information given in l) to n) in the same way or this information shall be available via the display of the meter.

NOTE 1 If the marking is external, it is not essential that it is normally visible to the user when the meter is correctly installed, but it is essential that it is clearly accessible and visible when the meter is being installed.

a) The manufacturer's name or trade mark and the place of manufacture.

b) The designation of type (see **3.10.7**).

NOTE 2 Space may be left for an approval mark.

c) The number of phases and the number of wires for which the meter is suitable (e.g. single-phase 2-wire, three-phase 3-wire, three-phase 4-wire).

If the meter is suitable for use on multiple connection systems, such as three-phase 3 or 4 wire, either all possible systems shall be stated (with any limitations) or the meter shall be marked with the relevant symbol referring the user to the supplied documentation in accordance with ISO 7000:2004, 0434.

NOTE 3 Standard symbols may also be used (see BS EN 62053-52).

d) The serial number and year of manufacture. If the serial number is marked on a plate fixed to the cover, the number shall also be marked on the meter base.

e) The reference voltage in one of the following forms:

- the number of measuring elements if more than one, and the voltage at the meter terminals of the voltage circuit(s);
- the rated voltage of the system or the secondary voltage of the instrument transformer to which the meter is intended to be connected.

NOTE 4 Examples of markings are shown in Table 14.

f) For direct connected meters, the basic current and the maximum current expressed, for example, thus: 10-40 A or 10(40) A for a meter having a basic current of 10 A and a maximum current of 40 A and for transformer-operated meters, the rated secondary current of the transformer(s) to which the meter should be connected, for example /5 A.

NOTE 5 The basic current and the maximum current of the meter may be included in the type designation.

g) The reference frequency or frequency range in Hz or kHz.

h) If all parameters are measured to the same accuracy, the class index. If different class indices apply to different parameters, and all the different class indices are not shown, the class index of the primary measured parameter shall be given together with details of that parameter and the relevant symbol referring the user to the supplied documentation (see ISO 7000:2004, 0434).

i) The reference temperature if different from 23 °C.

j) The sign of the double square for insulating encased meters of protective class II (see IEC 60417:1999, 5172).

k) Where the meter requires an auxiliary supply voltage for operation, the value and operating range of this voltage and of its frequency range.

l) The meter constant.

NOTE 6 The meter constant could be expressed, for example, in the form x Wh/imp or x imp/kWh where x is a nominal symbol.

m) Where the meter is fitted with one or more pulse outputs, the energy associated with each pulse, for example in the form: *x* Wh/imp or *x* imp/kWh.

n) Where the meter registers energy through instrument transformers of which account is taken in the meter, the transformation ratio(s), the primary values or the energy scaling constant.

Table 14 **Voltage marking**

Meter type	Voltage at the terminals of the voltage circuit(s) V	Rated system voltage V
Single-phase 2-wire 120 V	120	120
Single-phase 3-wire 120 V (120 V to the mid-wire)	240	240
Three-phase 3-wire 2-element (400 V between phases)	2 × 400	3 × 400
Three-phase 4-wire 3-element (230 V phase to neutral)	3 × 230 (400)	3 × 230/400

Markings shall remain clear and legible under conditions of normal use and resist the effects of cleaning agents specified by the manufacturer. Meter markings shall be tested for their durability in accordance with BS EN 61010-1:2010, **5.3**. After testing, the markings shall be clearly legible and adhesive labels shall not have worked loose or become curled at the edges.

If the meter is of a special type (e.g. in the case of a multi-rate meter, if the voltage of the change-over device differs from the reference voltage), this shall be marked on the meter.

12.2 Connection diagrams and terminal marking

Meters shall either be indelibly marked with a diagram of connections or a diagram of connections shall be included in the documentation supplied with the meter (see Clause **13**). For polyphase meters, this diagram shall also show the phase sequence for which the meter is intended.

NOTE 1 It is permissible to indicate the connection diagram by an identification figure in accordance with BS EN 62053-52.

If the meter terminals are marked, this marking shall appear on the diagram of connections.

NOTE 2 Where the meter can be used in multiple configurations, and all configurations are not shown on the meter, the user should be referred to the supplied documentation by use of the relevant symbol (ISO 7000:2004, 0434).

13 Accompanying documentation

Documentation shall be supplied with the meter providing all of the necessary instructions covering the safe installation and operation of the meter. It shall also include the following information.

a) If applicable, warning statements and a clear explanation of warning symbols. In particular, there shall be a statement that accompanying documentation needs to be consulted in all cases where symbol ISO 7000:2004, 0434, is used, in order to find out the nature of the potential hazard and any actions which need to be taken.

b) The definitions and equations used in calculating all powers and all energies measured by the meter shall be specified.

c) The reference frequency.

d) If the meter is fitted with an analogue output with a current signal, the compliance voltage.

e) If the meter is fitted with an analogue output, the response time. This shall be included for both increasing and decreasing inputs if different.

f) If the meter is fitted with a digital output, the response time. This shall be included for both increasing and decreasing inputs if different.

g) If the meter is fitted with a digital output, any averaging or filtering if used.

h) For the test output, the necessary number of pulses to ensure a measuring accuracy of at least one tenth of the class of the meter at the different test points.

i) The measurement technique category used by the meter (see **9.2.10**).

j) Where the meter is designed for mounting within a panel or enclosure, necessary instructions to ensure adequate precautions against penetration of dust and water (see **5.8)**.

NOTE Examples of such meters are those designed for mounting on a DIN rail.

k) Any accessories essential for the correct operation of the meter (see **C.1**).

l) The connection systems for which the meter is suitable if these are not all marked on the meter [see **12.1**c)].

m) The different accuracy class indices for the parameters measured by the meter if these are not marked on the meter [see **12.1**c) and **12.1**h)].

n) Diagram or diagrams of connections if these are not marked on the meter (see **12.2**).

Annex A (normative) Tests of mechanical requirements

A.1 Shock test

Meters shall be tested in accordance with **F.2**.

A.2 Vibration test

Meters shall be tested in accordance with BS EN 60068-2-6 under the following conditions.

- The meter shall be in its non-operating condition, without the packing.
- The frequency range shall be 10 Hz to 150 Hz.
- The transition frequency shall be 60 Hz.
- Where the frequency is less than 60 Hz, there shall be a constant amplitude of movement of 0.075 mm.
- Where the frequency is greater than 60 Hz, there shall be a constant acceleration of 9.8 m/s^2 (1 g).
- There shall be single point control.
- The number of sweep cycles per axis shall be ten.

  NOTE Ten sweep cycles correspond to 75 min.

A.3 Test of protection against penetration of dust

Meters shall be tested in accordance with BS EN 60529 under the following conditions.

- The meter shall be in a non-operating condition and mounted on an artificial wall or in a panel as applicable.
- For all apart from panel mounted meters, the test shall be conducted with sample lengths of cable (exposed ends sealed) fitted to the meter. The cable type shall be as specified by the manufacturer.
- For indoor meters, the same atmospheric pressure shall be maintained inside the meter as outside (neither under-pressure nor over-pressure).
- The first characteristic digit shall be 5 (IP5X) for indoor meters and 6 (IP6X) for outdoor meters.

A.4 Test of protection against penetration of water

Meters shall be tested in accordance with BS EN 60529 under the following conditions.

- The meter shall be in a non-operating condition and mounted on an artificial wall or in a panel as applicable.
- The second characteristic digit shall be 1 (IPX1) for indoor meters and 5 (IPX5) for outdoor meters.

Annex B (normative) Tests of climatic influences

B.1 Dry heat test

Meters shall be tested in accordance with BS EN 60068-2-2 in a non-operating condition at a temperature of (+70 ±2) °C for 72 h.

B.2 Cold test

Meters shall be tested in accordance with BS EN 60068-2-1 in a non-operating condition at a temperature of (–25 ±3) °C for 72 h.

B.3 Damp heat cyclic test

Meters shall be tested in accordance with BS EN 60068-2-30, under the following conditions.

- The voltage and auxiliary circuits shall be energized with the reference voltage without any current in the current circuits.
- The variant shall be 1.
- The upper temperature shall be (+40 ±2) °C for indoor meters and shall be (+55 ±2) °C for outdoor meters.
- No special precautions regarding the removal of surface moisture shall be taken.
- The duration of the test shall be six cycles.

B.4 Solar radiation test

Meters shall be tested in accordance with BS EN 60068-2-5:2000, test procedure A, (8 h radiation and 16 h darkness) under the following conditions.

- The meter shall be in a non-operating condition.
- The maximum temperature of the meter during this test shall be +55 °C.
- The duration of the test shall be three cycles or three days.

Annex C (normative) Tests of electrical requirements

C.1 General

Where a meter requires an accessory or accessories in order to operate correctly under practical conditions, any testing shall be carried out on both the instrument and the necessary accessory or accessories. Details of necessary accessories shall be specified in the documentation accompanying the meter.

NOTE 1 For example, where it is essential for a meter to be used with external current transformers in order for it to operate correctly (for reasons of design and not isolation levels), all tests would need to be carried out on a meter together with typical current transformers.

Where a meter is fitted with more than one output, the accuracy of all outputs shall be tested.

NOTE 2 "Outputs" here includes all methods of transmitting information from the meter to the outside including display, analogue output, digital output, pulse output and alarm outputs.

C.2 Test of power consumption

The power consumption in the voltage and current circuit shall be determined at reference values of the influence quantities given in **E.1**. The accuracy of measurement shall be no worse than 5%.

C.3 Tests of influence of supply voltage

If the meter requires an auxiliary supply voltage for operation, the dips and interruptions shall be applied synchronously to both the auxiliary supply and measurement voltage input terminals.

- The voltage and auxiliary circuits shall be energized with the reference voltage.
- There shall be no current in the current circuits. The tests detailed in a), b) and c) shall be carried out.
  a) Three voltage interruptions of ΔU = 100% and interruption time 1 s with 50 ms between interruptions shall be applied.
  b) One voltage interruption of ΔU = 100% and interruption time 20 ms shall be applied. Where a meter is being tested at a frequency in the range 45 Hz to 65 Hz, the interruption time shall be 1 cycle.
  c) One voltage dip of ΔU = 50% and dip time 1 min shall be applied.

NOTE 1 See Figure C.1, Figure C.2 and Figure C.3.

NOTE 2 If the meter requires an auxiliary supply voltage for operation, the voltage dips and short interruptions should be applied to both the auxiliary supply and the voltage measurement circuits, both separately and jointly.

Figure C.1 **Voltage interruptions of ΔU = 100%, 1 s**

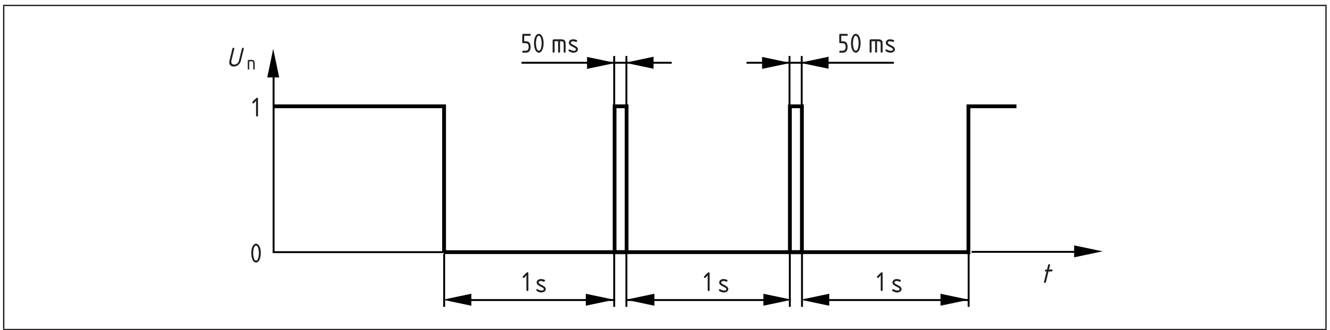
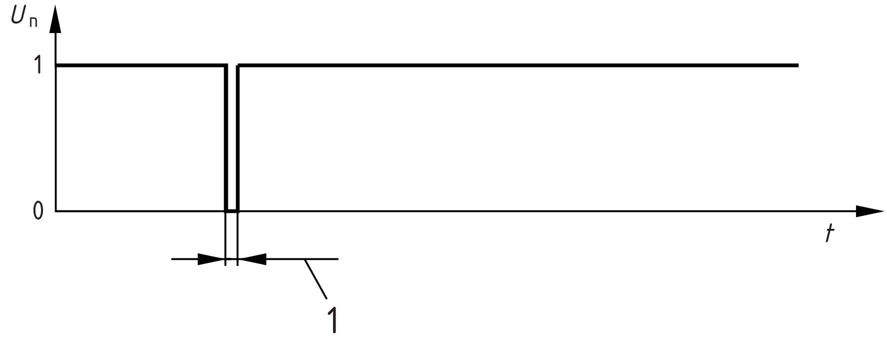


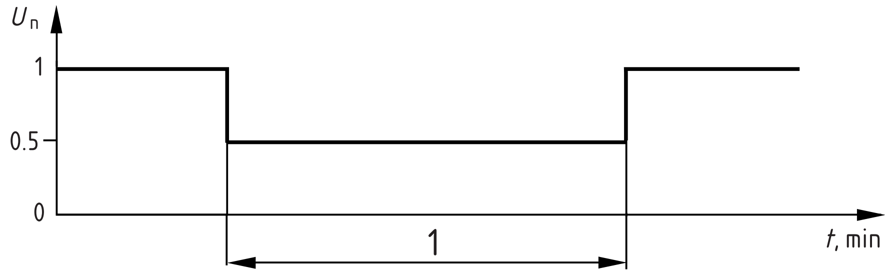
Figure C.2 **Voltage interruptions of ∆U = 100%, 20 ms (or 1 cycle)**



Key

1 20 ms or 1 cycle

Figure C.3 **Voltage dips of ∆U = 50%**



Key

1 Dip time (1 min)

C.4 Test of influence of short-time over-currents

The test circuit shall be non-inductive, as far as is practicable. The tests detailed in a) and b) shall be carried out.

a) For direct connection meters, a short-time over-current of 30 I_{max} for one half-cycle at rated frequency or 10 ms at frequencies below 15 Hz shall be applied with the voltage maintained at the terminals.

b) For meters for connection through a current transformer, a current equal to 20 times the maximum current shall be applied for 0.5 s.

The meter shall be allowed to return to its initial temperature with the voltage circuit(s) energized.

NOTE It normally takes about 1 h for the meter to return to its initial temperature.

C.5 Test of influence of self-heating

If the meter requires an auxiliary supply voltage for operation, the test shall be applied to the auxiliary supply input terminals as well as the measurement voltage terminals.

After the voltage circuits have been energized at reference voltage for at least 2/N h, where N is the meter accuracy class, without any current in the current circuits, the maximum current shall be applied to the current circuits. The meter error shall be measured at unity power factor immediately after the current is applied and then at intervals short enough to allow an accurate drawing to be made of the curve of error variation as a function of time. The test shall be carried out for at least 1 h, and until the variation of error during 20 min does not exceed 0.2%.

The test shall be repeated with a (lagging) power factor of 0.5.

C.6 Test of influence of heating

Each current circuit of the meter shall carry the maximum current and each voltage circuit, and auxiliary voltage circuits that are energized for periods of longer duration than their thermal time constants, shall carry 1.15 times the reference voltage for 2 h at an ambient temperature of 40 °C.

The meter shall not be exposed to draughts or direct solar radiation for the duration of the test.

C.7 Test of analogue output

NOTE Accuracy testing of analogue outputs may be carried out at the same time as the accuracy and performance of the meter is tested.

C.7.1 General

Meters shall be tested under reference conditions.

C.7.2 Test of ripple content

The ripple content of the analogue output shall be tested at rated minimum and maximum values of the output. The ripple content shall be measured as a peak-to-peak value.

C.7.3 Test of limit value of analogue output

The limiting value of the analogue output shall be tested by varying the input parameter between minimum and maximum values. Any programmable features of the output, such as input offset or full scale value, shall be set so as to provide the maximum overloads.

C.7.4 Test of compliance voltage and effect of variation of load

This test shall only be carried out on meters with analogue outputs that are a current signal.

Testing shall be carried at the minimum and maximum (low and high) values of the analogue output. At each point the output load resistance shall be set at 10% and 90% of its specified maximum value.

- The supply voltage for the analogue output, if supplied from a source external to the meter, shall be set to its minimum and maximum specified values.
- The supply to the meter, be it an auxiliary supply or derived from the voltage measurement inputs, shall be set to its minimum and maximum values in accordance with the operating range as defined in **7.3.1**.

The worst case maximum and minimum readings at the low and high outputs shall be noted.

The percentage error *E* shall be determined using the following equation:

$$E = \frac{N - W}{U} \times 100$$

where *N* is the nominal signal, *W* is the worst case signal and *U* is the output span.

C.7.5 Tests of analogue output response time

The response time for an increasing input shall be determined for an input step intended to produce a change in output signal from 0% to 100% of the output range as the time for the output to reach 90% of the output range.

The response time for a decreasing input shall be determined for an input step intended to produce a change in output signal from 100% to 0% of the output range as the time for the output to reach 10% of the output range.

C.8 Test of digital output

NOTE Accuracy testing of digital outputs may be carried out at the same time as the accuracy and performance of the meter is tested.

C.8.1 General

Meters shall be tested under reference conditions.

C.8.2 Tests of digital output response time

The response time for an increasing input shall be determined for an input step intended to produce a change in output signal from 0% to 100% of the output range as the time for the output to reach 90% of the output range.

The response time for a decreasing input shall be determined for an input step intended to produce a change in output signal from 100% to 0% of the output range as the time for the output to reach 10% of the output range.

Tests shall be repeated ten times, and the longest response time measured shall be taken.

C.9 Test of immunity to earth fault

This test shall only apply to meters which are to be used in networks equipped with earth fault neutralisers.

For three-phase 4-wire transformer operated meters, connected to distribution networks which are equipped with earth fault neutralizers or in which the star point is isolated, the following requirements shall apply.

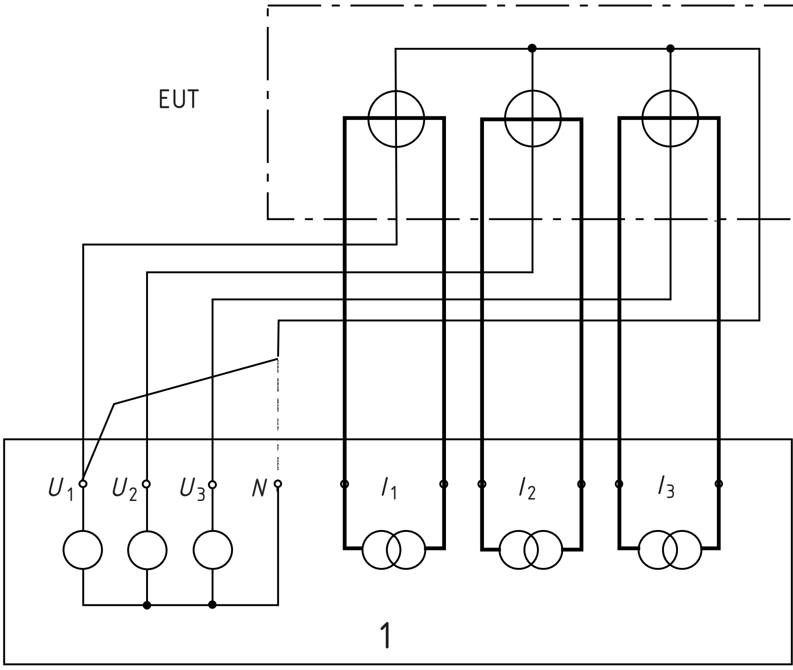
NOTE 1 In the case of an earth fault when there is 10% overvoltage, the line to earth voltage of the two lines which are not affected by the earth fault rises to 1.9 times the nominal voltage.

All voltages shall be increased to 1.1 times the nominal voltage for 4 h, under simulated earth fault conditions in one of the three lines. The neutral terminal of the meter under test shall be disconnected from the ground terminal of the meter test equipment (MTE) and connected to the MTE's line terminal at which the earth fault has to be simulated (see Figure C.4).

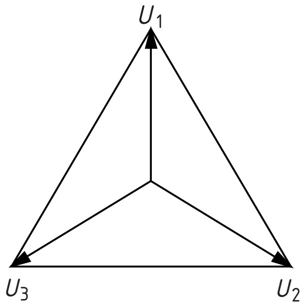
NOTE 2 In this way, the two voltage terminals of the meter under test which are not affected by the earth fault are connected to 1.9 times the nominal phase voltages.

The current circuits shall be set to 50% of the rated current I_n, phase influence function 1 and symmetrical load.

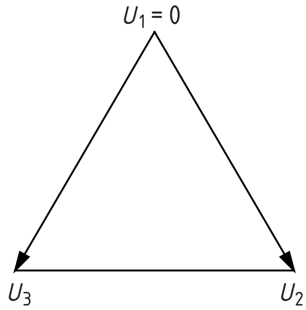
Figure C.4 **Test circuit diagram for the test of immunity to earth fault**



a) Test circuit diagram



b) Voltages at the meter under test: normal condition



c) Voltages at the meter under test: earth fault condition

Key

1 Meter test equipment

Annex D (normative) Tests for electromagnetic compatibility (EMC)

D.1 General test conditions

For the tests of **D.2** to **D.8**, the meter shall be in its normal working position with the cover and terminal covers in place, unless otherwise specified. All parts intended to be earthed shall be earthed.

D.2 Test of immunity to electrostatic discharges

The meter shall be tested in accordance with BS EN 61000-4-2, under the following conditions:

- tested as table-top equipment;
- meter in operating condition;
- voltage and auxiliary circuits energized with reference voltage;
- without any current in the current circuits (open circuit);
- contact discharge;
- a test voltage of 8 kV;
- number of discharges of 10 (in the most sensitive polarity).

If contact discharge is not applicable because no metallic parts are outside, air discharge shall be applied with a 15 kV test voltage.

D.3 Test of immunity to electromagnetic RF fields

The meter shall be tested in accordance with BS EN 61000-4-3, under the following conditions:

- tested as table-top equipment;
- cable length, exposed to the field: 1 m;
- voltage and auxiliary circuits energized with the reference voltage;
- a frequency band of 80 MHz to 2 000 MHz;
- carrier modulated with 80% AM at 1 kHz sine wave.

Meters shall be tested in their operating condition:

a) without any current in the current circuits and with the current terminals on open circuit and unmodulated test field strength of 30 V/m;

b) with basic current I_b, respectively rated current I_n, phase influence function equal to 1 and unmodulated test field strength of 10 V/m.

D.4 Fast transient burst test

The meter shall be tested in accordance with BS EN 61000-4-4, under the following conditions.

The test voltage shall be applied in common mode to earth to:

- the voltage measuring circuits, all inputs simultaneously;
- if fitted, the auxiliary supply voltage circuits;
- the current circuits, if separated from the voltage measuring circuits in normal operation, all inputs simultaneously;
- the communications ports if fitted, all ports simultaneously;

- the pulse and other auxiliary outputs if fitted, all outputs simultaneously;
- any other auxiliary circuits if fitted and if separated from the voltage measuring circuits in normal operation, all inputs simultaneously.

Any ports which might in normal use be connected directly to the power system shall be directly coupled to the test voltage. Ports which are not directly connected to the power system shall be tested using a capacitive coupling clamp. Meters shall be tested under the conditions of a) and b).

a) With basic current I_b, respectively rated current I_n, and phase influence function equal to 1:
   - tested as table-top equipment;
   - meter in operating condition;
   - voltage and auxiliary circuits energized with reference voltage;
   - cable length between coupling device and EUT: 1 m;
   - test voltage applied in common mode (line to earth);
   - test voltage on the current and voltage circuits: 4 kV;
   - test voltage on the auxiliary circuits with a reference voltage over 40 V: 2 kV;
   - for capacitively coupled inputs the test voltage shall be 2 kV;
   - duration of the test: 60 s at each polarity.

b) Without any current in the current circuits and the current terminals on open circuit:
   - tested as table-top equipment;
   - meter in operating condition;
   - voltage and auxiliary circuits energized with reference voltage;
   - test voltage on the current and voltage circuits: 4 kV;
   - test voltage on the auxiliary circuits with a reference voltage over 40 V: 2 kV;
   - for capacitively coupled inputs the test voltage shall be 2 kV;
   - duration of the test: 60 s at each polarity.

D.5 Test of immunity to conducted disturbances, induced by RF fields

The meter shall be tested in accordance with BS EN 61000-4-6, under the following conditions:

- tested as table-top equipment;
- meter in operating condition;
- voltage and auxiliary circuits energized with reference voltage;
- with basic current $I_{b,}$ respectively rated current I_n, and phase influence function equal to 1;
- frequency range: 150 kHz to 80 MHz;
- voltage level: 10 V.

D.6 Surge immunity test

The meter shall be tested in accordance with BS EN 61000-4-5, under the following conditions:

- meter in operating condition;
- voltage and auxiliary circuits energized with reference voltage;
- without any current in the current circuits and the current terminals shall be open circuit;
- cable length between surge generator and meter: 1 m;
- tested in differential mode (line to line);
- for an a.c. meter, phase angle: pulses to be applied at 60° and 240° relative to zero crossing of AC supply;
- test voltage on the current and voltage circuits (mains lines): 4 kV, generator source impedance: 2 Ω;
- test voltage on auxiliary circuits with a reference voltage over 40 V: 1 kV; generator source impedance: 42 Ω;
- number of tests: 5 positive and 5 negative;
- repetition rate: maximum 1/min.

D.7 Damped oscillatory waves immunity test

The meter shall be tested in accordance with BS EN 61000-4-18 under the following conditions:

- only for transformer operated meters;
- tested as table top equipment;
- meter in operating condition;
- voltage and auxiliary circuits energized with reference voltage;
- with rated current I_n and phase influence function equal to 1;
- test voltage on voltage circuits and auxiliary circuits with a reference voltage >40 V:
  - common mode: 2.5 kV;
  - differential mode: 1.0 kV;
- test frequencies:
  - 100 kHz, repetition rate: 40 Hz;
  - 1 MHz, repetition rate: 400 Hz;
- test duration: 60 s (15 cycles with 2 s on, 2 s off, for each frequency).

D.8 Radio interference measurement

The meter shall be tested in accordance with BS EN 55022, for class B equipment, under the following conditions:

- tested as table-top equipment;
- meter in operating conditions;
- voltage and auxiliary circuits energized with reference voltage and connected by an unshielded cable of length of 1 m;
- with a current between 0.1 I_b and 0.2 I_b, respectively 0.1 I_n and 0.2 I_n (drawn by linear load and connected by unshielded cable length of 1 m).

Annex E (normative) Tests of accuracy requirements

E.1 General test conditions

To test the accuracy requirements as specified in Clause **9**, the following test conditions shall be maintained.

a) The meter shall be tested in its case with the cover in position; all parts intended to be earthed shall be earthed.

b) Before any test is made, the circuits shall have been energized for a time sufficient to reach thermal stability.

c) In addition, for polyphase meters:

- the phase sequence shall be as marked on the diagram of connections;
- the voltages and currents shall be substantially balanced;
- each of the voltages between the phases and neutral and between any two phases shall not differ from the average corresponding voltage by more than ±1.0%;
- each of the currents in the conductors shall not differ from the average current by more than ±2.0%;
- the phase displacement of each of these currents from the corresponding phase-to-neutral voltage, irrespective of the phase angle, shall not differ from each other by more than 2°.

NOTE 1 The reference conditions are given in Table 13.

NOTE 2 For requirements regarding test stations, see IEC 736.

E.2 Test of influence quantities

E.2.1 General

The tests in **E.2** shall be carried out in order to verify that the influence quantity requirements as specified in **9.1.5** and **9.2** are satisfied.

Tests for variation caused by influence quantities shall be performed independently with all other influence quantities at their reference conditions (see Table 13). If the tests are made at a temperature other than the reference temperature, including permissible tolerances, the tests shall be corrected by applying the appropriate temperature coefficient.

E.2.2 Accuracy test for net active power in the presence of harmonics

NOTE 1 This test does not apply to meters only measuring d.c.

Meters shall be tested under the following test conditions:

- fundamental frequency current: $I_1 = 0.5\ I_{max}$;
- fundamental frequency voltage: $U_1 = U_n$;
- fundamental frequency phase influence function: –1 (export);
- content of 5th harmonic voltage: U_5 = 10% of U_n;
- content of 5th harmonic current: I_5 = 40% of fundamental current;

- harmonic phase influence function: 1;
- fundamental and harmonic voltages are in phase at positive zero crossing.

NOTE 2 Resulting harmonic power and total power due to the 5^{th} harmonic, P_5, is determined by the following equation:

$$P_5 = 0.1\ U_o \times 0.4\ I_o = 0.04\ P_0$$

and the total power is 0.96 P_0.

E.2.3 Tests of the influence of odd harmonics and sub-harmonics

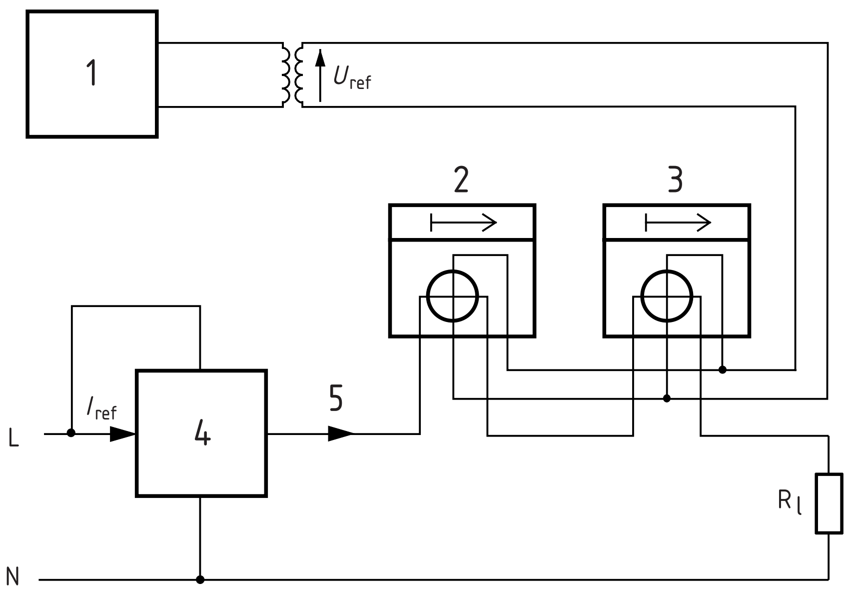
The meter shall be tested for the influence of odd harmonics with the circuit shown in Figure E.1 or with other equipment able to generate the required waveforms, and the current waveforms as shown in Figure E.2, having a harmonic content as shown in Figure E.3.

The meter shall be tested for the influence of sub-harmonics with the circuit shown in Figure E.1 or with other equipment able to generate the required waveforms, and the current waveforms as shown in Figure E.4, having a harmonic content as shown in Figure E.5.

The tests for the influence of odd harmonics and sub-harmonics shall only be used when testing influence effects on a.c. measurement accuracy.

The standard meter shall measure true energy (fundamental plus harmonics) in the presence of harmonics.

Figure E.1 **Test circuit diagram for determining the influence on accuracy of odd harmonics or sub-harmonics in the current circuit**



Key

1 Voltage waveform generator

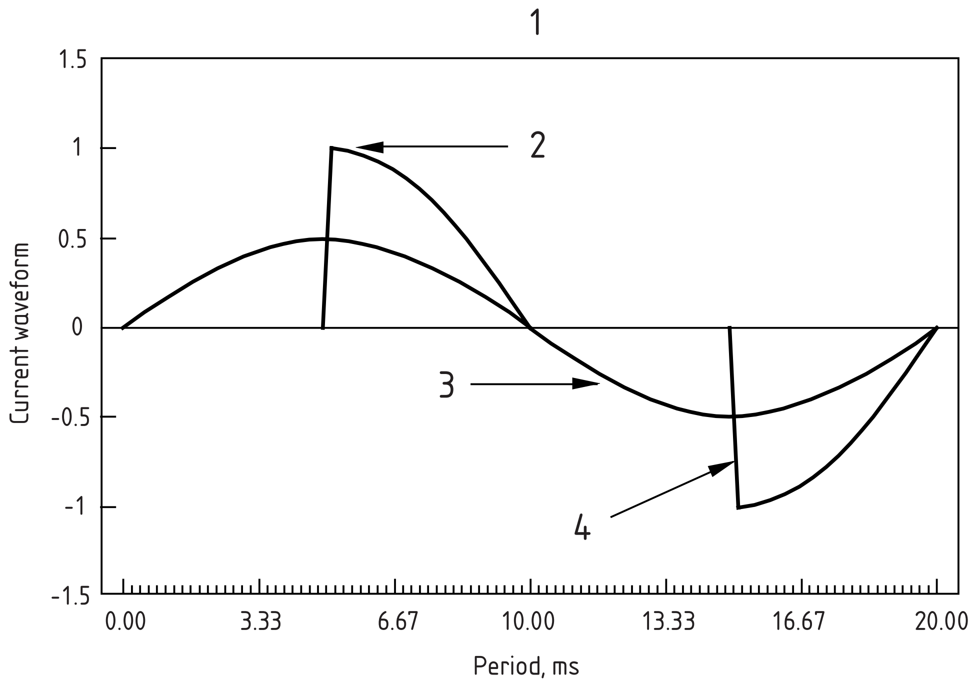
2 Standard meter

3 Equipment under test (EUT)

4 Current waveform generator

5 I_{ref} or I_{test}

Figure E.2 **Phase-fired waveform (shown for 50Hz)**



Key

1 Fired at 5 ms and 15 ms

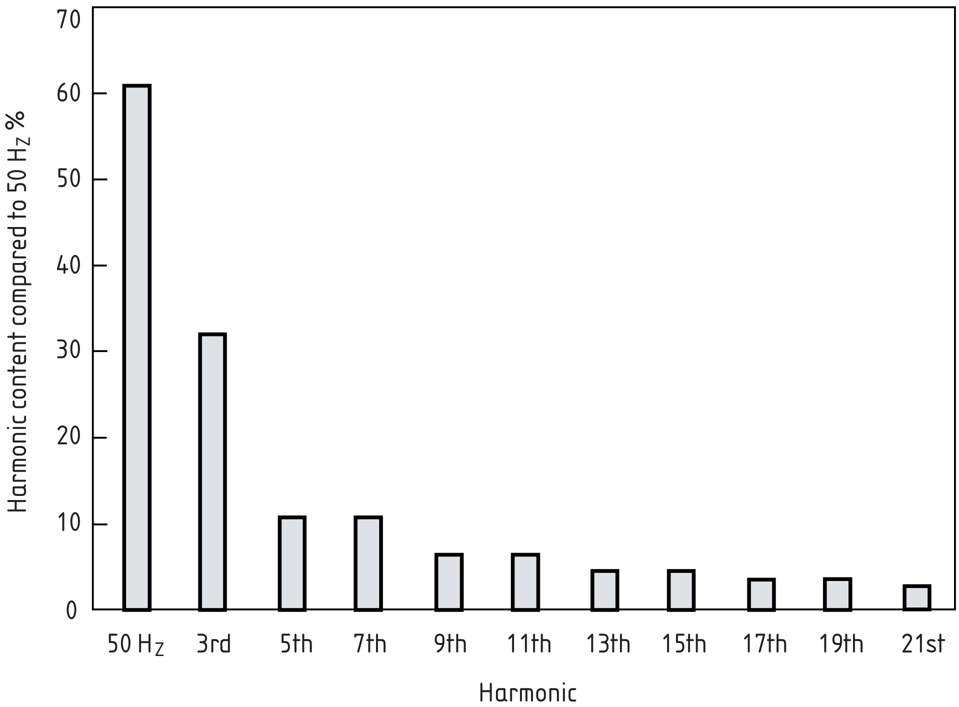
2 Test current waveform (I_b or I_n)

3 Reference waveform (0.5 I_b or 0.5 I_n)

4 Rise time of leading edge (0.2 ±0.1) ms; Firing points are (5 ±0.1) ms and (15 ±0.1) ms

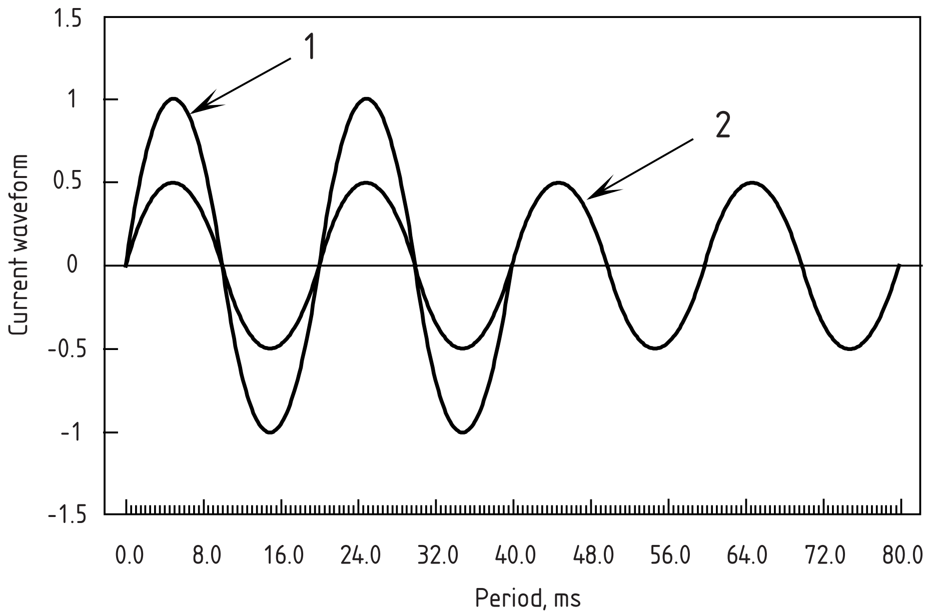
NOTE This figure is shown for 50 Hz. Where the meter is designed for alternative frequencies or frequency ranges, the above should be adjusted to match the reference frequency.

Figure E.3 **Analysis of harmonic content of phase-fired waveform (shown for 50Hz)**



NOTE This figure is shown for 50 Hz. Where the meter is designed for alternative frequencies or frequency ranges, the above should be adjusted to match the reference frequency.

Figure E.4 **Burst fire waveform (shown for 50Hz)**



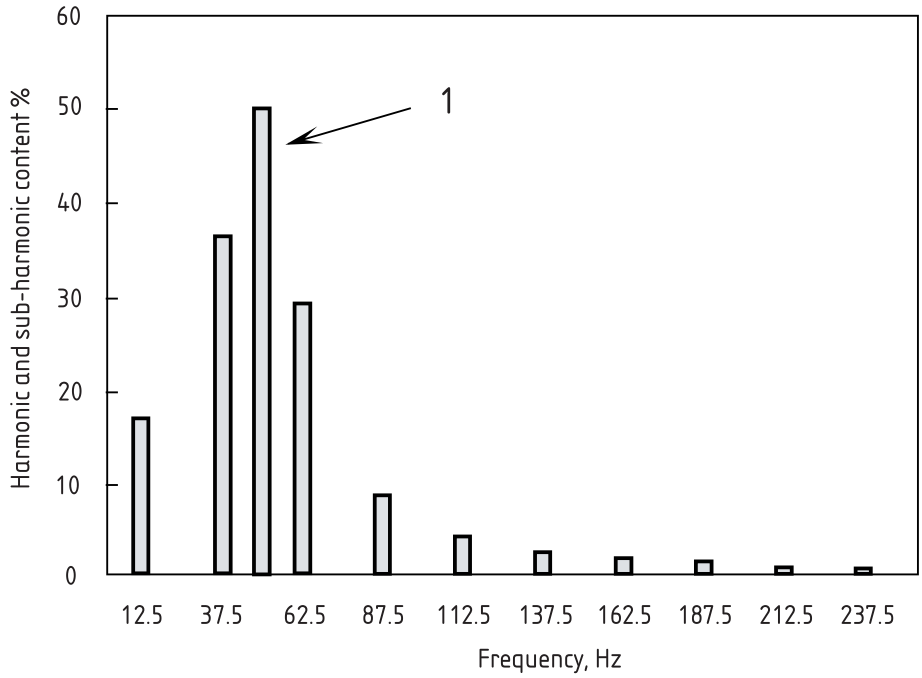
Key

1 Current waveform

2 Voltage waveform

NOTE This figure is shown for 50 Hz. Where the meter is designed for alternative frequencies or frequency ranges, the above should be adjusted to match the reference frequency.

Figure E.5 **Analysis of harmonics (shown for 50Hz)**



Key

1 50 Hz component

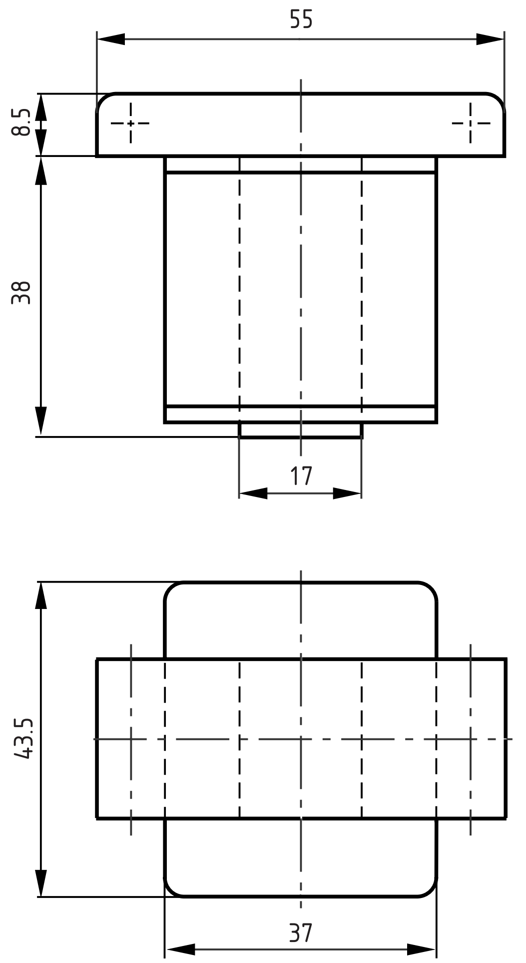
NOTE This figure is shown for 50 Hz. Where the meter is designed for alternative frequencies or frequency ranges, the above should be adjusted to match the reference frequency.

E.2.4 Continuous magnetic induction of external origin

The continuous magnetic induction shall be obtained by using an electromagnet as shown in Figure E.6, energized with a d.c. current. This magnetic field shall be applied to all accessible surfaces of the meter when it is mounted as for normal use. A magneto-motive force of 1 000 ampere-turns shall be applied to the meter.

Figure E.6 **Electromagnet for testing the influence of externally produced magnetic fields**

Scale 1:1. Dimensions in millimetres.



Key

1 Meter under test

NOTE Examples of winding: 500 turns 0.6 Ø /0.28 mm² or: 1 000 turns 0.4 Ø /0.126 mm².
Core lamination: 1.0 W/kg.

E.2.5 Magnetic induction of external origin

The meter shall be placed in the centre of a circular coil, 1 m in mean diameter, of square section and of small radial thickness relative to the diameter, and having 400 ampere-turns, in order to obtain the necessary magnetic induction.

E.3 Test of no-load condition

The current circuit shall be open circuit and a voltage of 115% of the reference voltage (or 115% of the upper limit of the voltage range) shall be applied to the voltage circuits for a time, Δt, in minutes given by the equation:

$$\Delta t \geq \frac{\{360 + (240 / N)\} \times 10^6}{k \cdot m \cdot U_n \cdot I_{max}}$$

where

- k is the number of pulses emitted by the output device of the meter per kWh (or kvarh, or kVAh, etc.) imp/kWh or imp/kvarh, etc.;
- m is the number of measuring elements;
- U_n is the reference voltage in volts;
- I_{max} is the maximum current in amperes;
- N is the class of the meter.

For transformer-operated meters with primary or half primary registers, the constant k shall correspond to the secondary values (voltage and current).

E.4 Test of starting condition

The reference voltage and the current specified in Table 12 shall be applied to the meter.

E.5 Test of meter constant

It shall be verified that the relation between the test output and the indication on the display conforms to the marking on the name-plate.

E.6 Test of measurement technique

NOTE 1 Where any doubt exists as to the measurement technique used, this can be verified by the following test.

The meter shall be tested with the circuit shown in Figure E.1 or with other equipment able to generate the required waveforms.

The standard meter shall be a meter, such as a Ferraris electromechanical meter, which is known to use a continuous measurement technique.

The voltage and current generators shall generate random phase fired signals. The random signal generators shall be set such that the average voltage and current over the test period is (50 ±5)% of the continuous signal.

The test duration shall be 2 h.

NOTE 2 Where the meter under test is a polyphase meter, the standard meter may also be a polyphase meter or multiple single phase meters.

The test shall be carried out both with signals synchronized across all phases, and with separate random generators for each phase.

The measurement error shall be calculated.

Annex F (normative) Tests of safety requirements

F.1 General

The safety requirements of meters shall be tested in accordance with BS EN 61010-1 and BS EN 61010-2-030 with the variations and additions given in **F.2**, **F.3** and **F.4**.

F.2 Mechanical resistance to shock and impact

Meters shall be tested according to BS EN 61010-1:2010, Clause **8**. Meters (unless designed for portable use) shall be considered as fixed equipment for the purpose of the drop test.

If the meter is manufactured in a proprietary enclosure, and the manufacturer of the enclosure (or other party) provides documentary evidence as to conformity to the requirements of this test, this shall be deemed acceptable.

F.3 Test of resistance to heat and fire

Meters shall be tested according to BS EN 61010-1:2010, Clause **9**. Meters (unless designed for portable use) shall be considered as permanently connected equipment for the purpose of the test for over-current protection.

F.4 Tests of insulation properties

F.4.1 General

Meters shall be tested for insulation properties, and general electrical safety according to the applicable sections of BS EN 61010-1 and BS EN 61010-2-030, measurement category III.

F.4.2 Test conditions

F.4.2.1 General

The tests on insulation properties shall be carried out only on a complete meter, with its cover (except when indicated hereafter) and terminal cover, the terminal screws being screwed down to the maximum applicable conductor fitted in the terminals.

The impulse voltage tests shall be carried out first and the a.c. voltage tests afterwards.

During type tests, the dielectric strength tests shall be valid only for the terminal arrangement of the meter which has undergone the tests. When the terminal arrangements differ, all the dielectric strength tests shall be carried out for each arrangement.

For the purpose of these tests, the term "earth" shall have the following meaning:

a) when the meter case is made of metal, the "earth" is the case itself, placed on a flat conducting surface;

b) when the meter case or only a part of it is made of insulating material, the "earth" is a conductive foil wrapped around the meter and connected to the flat conducting surface on which the meter base is placed. Where the terminal cover makes it possible, the conductive foil shall approach the terminals and the holes for the conductors within a distance of not more than 2 cm.

During the impulse and the a.c. voltage tests, the circuits which are not under test shall be connected to the earth as indicated hereafter. No flashover, disruptive discharge or puncture shall occur.

After these tests, there shall be no change at reference conditions in the percentage error of the meter greater than the uncertainty of the measurement.

These tests shall be made in normal conditions of use. During the test, the quality of the insulation shall not be impaired by dust or abnormal humidity.

Unless otherwise specified, the normal conditions for insulation tests shall be:

- ambient temperature from 15 °C to 25 °C;
- relative humidity from 45% to 75%;
- atmospheric pressure from 86 kPa to 106 kPa.

F.4.2.2 Voltage tests for circuits and between the circuits

The test shall be made independently on each circuit (or assembly of circuits) which is insulated from the other circuits of the meter in normal use. The terminals of the circuits which are not subjected to impulse voltage shall be connected to earth.

Thus, when the voltage and the current circuits of a measuring element are connected together in normal use, the test shall be made on the two circuits linked together. The other end of the voltage circuit shall be connected to earth and the impulse voltage shall be applied between the terminal of the current circuit and earth. When several voltage circuits of a meter have a common point, this point shall be connected to earth and the impulse voltage successively applied between each of the free ends of the connections (or the current circuit connected to it) and earth.

When the voltage and the current circuits of the same measuring element are separated and appropriately insulated in normal use (e.g. each circuit connected to a measuring transformer), the test shall be made separately on each circuit.

During the test of a current circuit, the terminals of the other circuits shall be connected to earth and the impulse voltage shall be applied between one of the terminals of the current circuit and earth. During the test of a voltage circuit, the terminals of the other circuits and one of the terminals of the voltage circuit under test shall be connected to earth and the impulse voltage shall be applied between the other terminal of the voltage circuit and earth.

The auxiliary circuits intended to be connected either directly to the mains or to the same voltage transformers as the meter circuits, and with a reference voltage over 40 V, shall be subjected to the impulse voltage test in the same conditions as those already given for voltage circuits. The other auxiliary circuits shall not be tested.

F.4.2.3 Voltage test of electric circuits relative to earth

All the terminals of the electric circuits of the meter, including those of the auxiliary circuits with a reference voltage over 40 V, shall be connected together.

NOTE The expression "all the terminals" means the whole set of terminals of the current circuits, voltage circuits and, if any, auxiliary circuits having a reference voltage over 40 V.

The auxiliary circuits with a reference voltage below or equal to 40 V shall be connected to earth. The impulse voltage shall be applied between all the electric circuits and earth.

F.4.3 Impulse voltage test

Impulse voltage tests shall be carried out on the meter in accordance with BS EN 61010-1 and BS EN 61010-2-030.

F.4.4 A.C. voltage test

A.C. voltage tests shall be carried out on the meter in accordance with BS EN 61010-1 and BS EN 61010-2-030.

Annex G (informative) Test schedule

Table G.1 gives the recommended sequence of tests to be carried out on meters. The tests should be carried out in sequence from the top to the bottom row of the table and the numbers in the first column reflect this.

Table G.1 **Recommended test sequences**

No.	Requirement under test	Test method
1	Safety requirements	**Annex F**
1.1	Safety testing in accordance with BS EN 61010-1 and BS EN 61010-2-030	
2	Accuracy and performance requirements: meter only	**Annex E**
2.1	Meter constant	**E.5**
2.2	Starting condition	**E.4**
2.3	No-load condition	**E.3**
2.4	Ambient temperature influence	**9.2.7**
2.5	Influence quantities	**E.2**
2.6	Test of measurement technique	**E.6**
3	Accuracy and performance requirements: outputs	
3.1	Analogue outputs	
3.1.1	Compliance voltage	**C.7.4**
3.1.2	Ripple content	**C.7.2**
3.1.3	Output response time	**C.7.5**
3.1.4	Influence quantities	**C.7**
3.1.5	Test of limit value of analogue output	**C.7.3**
3.2	Digital outputs	
3.2.1	Digital output response time	**C.8.2**
3.2.2	Influence quantities	**C.8**

Table G.1 **Recommended test sequences** *(continued)*

No.	Requirement under test	Test method
4	Electrical requirements	**Annex C**
4.1	Power consumption	**C.2**
4.2	Influence of supply voltage	**C.3**
4.3	Influence of short-time over-currents	**C.4**
4.4	Influence of self-heating	**C.5**
4.5	Influence of heating	**C.6**
4.6	Immunity to earth fault	**C.9**
5	Electromagnetic compatibility (EMC)	**Annex D**
5.1	Radio interference	**D.8**
5.2	Damped oscillatory waves	**D.7**
5.3	Surge immunity	**D.6**
5.4	Immunity to conducted disturbances, induced by RF fields	**D.5**
5.5	Fast transient burst	**D.4**
5.6	Immunity to electromagnetic RF fields	**D.3**
5.7	Immunity to electrostatic discharges	**D.2**
6	Climatic influences	**Annex B**
6.1	Dry heat	**B.1**
6.2	Cold	**B.2**
6.3	Damp heat cyclic test	**B.3**
6.4	Solar radiation	**B.4**
7	Mechanical requirements	**Annex A**
7.1	Vibration	**A.2**
7.2	Shock	**A.1**
7.3	Protection against penetration of dust	**A.3**
7.4	Protection against penetration of water	**A.4**

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3) Withdrawn. Referred to in Foreword only.

4) Not available in hard copy. Available by subscription at http://std.iec.ch.

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