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OIML International Recommendation 46

Electricity Meters

Draft Revision

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xx

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Explanatory Note

The former OIML Recommendation IR-46 "ACTIVE ELECTRICAL ENERGY METERS FOR DIRECT CONNECTION (CLASS 2)" was withdrawn by the CIML in 1997, because it was inconsistent with existing IEC standards and the metering technology development had made it outdated. Within OIML TC 12 a working group for the revision of the IR 46 has been formed, with members from most parts of the world, to ensure that the revised recommendation attains a wide acceptance.

In the absence of an updated OIML Recommendation, the electricity meters are presently tested against IEC standards or national or regional standards. A revised OIML Recommendation should have the possibility to be accepted in most parts of the world, bringing down testing costs for both manufacturers and nations and in the end the consumers. The drafted Recommendation relies heavily on IEC standards. However, the IEC standards for electricity meters are technology dependent and in the case of electromechanical meters rather old, and they are not used is some parts of the world. Further the legislator demands are changing and consumer interest is important within OIML. For these reasons it is not possible or desirable to use the IEC electricity meter requirements and tests in every case.

With newer designs including static meters and software control the variation within a "type" is much larger and "meter type" is harder to define. How much is it possible to change in a meter without the necessity for a new type test, and how software can be tested and secured, must somehow be addressed. Also, EMC, integrity and functionality have become much more important issues.

The working group for the revision of IR 46 of the OIML TC 12 started its work at a meeting in Borås, Sweden, in September 2002, where task-groups were formed for different parts of the standardisation work. An Internet workplace was set up. This is a restricted-access web-site where the working group members can freely download information and download, change and upload working documents. The input from the different task-groups was collected to a pre-draft that was discussed during the second meeting, which was held in Maastricht, March 27-28.

In Maastricht, most of the items in the pre-draft were discussed and decided upon or left to further work. The main discussions were about two topics, how to define the accuracy requirements and the level of allowed effects of influence quantities. There are quite a few influence quantities that could affect the accuracy, and it was argued that the maximum permissible error should cover all these conditions, or at least most of them. However, it is far from obvious that the effects of different influence quantities are independent from each other and therefore not obvious that one could measure the effect of each one and then sum them up by the root-mean-square law as proposed.

The concept of maximum permissible error was central to the process of making the new Recommendation. Several comments on this matter have been received, unfortunately with diverging content. In the resulting draft document some values have been reverted to IEC values but an overall requirement on temperature behaviour has also been added which satisfies Nordic needs and should also address the needs of US, Canada and Australia. The impact on meters intended for mild climate or indoor application will be negligible.

A third working group meeting was held in Copenhagen at the end of March 2004 where most of the major open questions were discussed and solved. As an outcome of this meeting, a first Committee Draft for the revised IR 46 has been agreed upon and is circulated to P- and O-members and liaison international bodies and external organisations for comments.

At the fourth meeting in Borås, Sweden, a second Committee Draft was revised based on the comments received. The areas where the approach or requirements of this Recommendation draft differs from other standards was extensively discussed.

At the fourth meeting in Ottawa, Canada, a further extensive revision was made to refine and precise the requirements and the tests.

Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States.

The two main categories of OIML publications are:

• International Recommendations (OIML R), which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity; the OIML Member States shall implement these Recommendations to the greatest possible extent;

• International Documents (OIML D), which are informative in nature and intended to improve the work of the metrological services.

OIML Draft Recommendations and Documents are developed by technical committees or subcommittees which are formed by the Member States. Certain international and regional institutions also participate on a consultation basis.

Cooperative agreements are established between OIML and certain institutions, such as ISO and IEC, with the objective of avoiding contradictory requirements; consequently, manufacturers and users of measuring instruments, test laboratories, etc. may apply simultaneously OIML publications and those of other institutions.

International Recommendations and International Documents are published in French (F) and English (E) and are subject to periodic revision.

This publication - reference OIML R 46, edition xxxx (E) – was developed by the Working Group on the Revision of R 46 of the OIML Technical Committee TC 12/WG 1 . It was approved for final publication by the International Committee of Legal Metrology in xxxx.

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Part 1
Metrological and technical requirements

1Scope

This document sets out requirements pertinent to metrological control of electricity meters intended for use in revenue metering. The requirements are to be applied during type approval, verification, and re-verification. They also apply to modifications that may be made to existing approved devices.

The provisions set out here apply to:

Electricity meters for active energy at power frequency. Meters can be direct connected for system voltages up to 690 V, or transformer operated. No distinction in requirements is made with respect to technology employed for the meter.

2Bibliography

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IEC 61000-4-11 (2004-03). Electromagnetic compatibility (EMC). Part 4-11: Testing and measurement techniques -: Voltage dips, short interruptions and voltage variation immunity tests. International Electrotechnical Commission, Geneva.

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IEC 61000-4-5 (2001-04) Ed. 1.1 Consolidated Edition Amendment IEC 61000-4-5-am1(2001-11). *Electromagnetic compatibility (EMC). Part 4-5: Testing and measurement techniques - Surge immunity test*. International Electrotechnical Commission, Geneva.

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3Terminology

The basic terminology used in this Recommendation is defined by the OIML International Document D11, General requirements for electronic measuring instruments, and conforms to the International Vocabulary of Basic and General Terms in Metrology (VIM) [1] and the Vocabulary of Legal Metrology (VML) [2]. In addition, for the purposes of this Recommendation, the following definitions shall apply:

3.1Meters and their constituents

3.1.1Electricity meter

An instrument intended to measure electrical energy continuously by integrating power with respect to time and to store the result.

Note: It is recognized that "continuously" may also cover meters with a sampling rate sufficiently high to fulfil the requirements of this Recommendation.

A meter will incorporate one or more of the following types of meters.

3.1.2Watt-hour meter

An electricity meter intended to measure and display active electrical energy. The active energy is normally displayed with the prefix kilo or Mega, as kWh or MWh.

Note: Since this Recommendation only deals with watt-hour meters, the short form "meter" is used.

3.1.3Demand meter

An electricity meter intended to measure.demand or maximum demand or both, where demand is the rate at which active electrical energy is supplied to a load and which displays and stores the demand(s).

3.1.4Interval meter

An electricity meter intended to measure electrical energy and which displays and stores the result as measured in predetermined time intervals.

3.1.5Prepayment meter

An electricity meter intended to allow electrical energy to be delivered up to a predetermined amount. Such instrument measures energy continuously and may store and display the measured energy.

3.1.6Multi tariff meter, multi-rate meter

An electricity meter intended to measure and display electrical energy where energy will have more than one tariff rate. The tariff rate may be determined by time, load or some other quantity.

3.1.7Direct connected meter

A meter intended for use by direct connection to the circuit being measured, without the use of external devices such as instrument transformers.

3.1.8Transformer operated meter

A meter intended for use with one or more external instrument transformers.

3.1.9Electromechanical meter

Meter in which currents in fixed coils react with the currents induced in the conducting moving element, generally (a) disk(s), which causes their movement proportional to the energy to be measured. (IEC62052-11)

3.1.10 Static meter

Meter in which current and voltage act on solid state (electronic) elements to produce an output proportional to the energy to be measured. (IEC62052-11)

3.1.11 Measuring element

Part of the meter that transforms a current and a voltage into a signal proportional to the power and or energy.

Note: A measuring element can be based on an electromagnetic, electrical or an electronic principle.

3.1.12 Current circuit

Internal connections of the meter and part of the measuring element through which flows the current of the circuit to which the meter is connected. (IEC62052-11)

3.1.13 Voltage circuit

Internal connections of the meter, part of the measuring element and in the case of static meters, part of the power supply, supplied with the voltage of the circuit to which the meter is connected. (IEC62052-11)

3.1.14 Indicating device, display

The part of the meter that displays the measurement results either continuously or on demand.

Note: An indicating device may also be used to display other relevant information.

3.1.15 Register

The part of the meter that stores the measured values. It can be an electromechanical device or an electronic device. The register may be integral to the indicating device.

3.1.16 Primary register

For transformer operated meters. A register where the scale factor(s) due to the used instrument transformer(s) is considered such that the measured energy on the primary side of the instrument transformer (s) is indicated.

3.1.17 Register multiplier

Is constant with which the register reading shall be multiplied to obtain the value of the metered energy.

3.1.18 Meter constant

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

3.1.19 Test output

A device which can be used for testing of the meter, providing pulses or the means to provide pulses corresponding to the energy measured by the meter.

3.1.20 Adjustment device

A device or function incorporated in the meter that allows the error curve to be shifted with a view to bringing errors (of indication) within the maximum permissible errors.

3.1.21 Ancillary device, auxiliary device

A device or function within the meter that is not part of the basic metrology function. The main ancillary devices are:

d) Communication for transmitting measurement data.;

e) Tariff changing controls;

f) Load control devices

Note: It is advised that ancillary devices are only subject to metrological control if they are used for trade.

3.2 Metrological characteristics

3.2.1 Current (I)

The electrical current flowing through the meter.

Note: The terms "current" and "voltage" in this Recommendation indicate r.m.s. values unless otherwise specified.

3.2.2 Starting current (I_{st})

The lowest value of current at which the meter is declared to register electrical energy at unity power factor and, for polyphase meters, with balanced load.

3.2.3 Minimum current (I_{min}), (Ed. alt. Low current (I_{low}))

The lowest declared value of current at which the mpe requirement is constant with regard to current variations.

3.2.4 Transitional current (I_{tr})

The declared value of current at and above which the meter purports to lie within the smallest maximum permissible error corresponding to the class index of the meter.

3.2.5 Maximum current (I_{max})

The highest declared value of current at which the meter purports to meet the accuracy requirements of this Recommendation.

3.2.6 Voltage (U)

The electrical voltage supplied to the meter.

3.2.7 Nominal voltage (U_{nom})

The declared voltage for which the meter is intended.

3.2.8 Frequency (f)

The frequency of the voltage(and current) supplied to the meter.

3.2.9 Nominal frequency (f_{nom})

The declared frequency of the voltage (and current) for which the meter is intended.

3.2.10 Harmonic

A part of a signal that has a frequency that is an integer number multiple of the fundamental frequency of the signal. The fundamental frequency is generally the reference frequency (f_{ref})

3.2.11 Harmonic number

An integer number used to identify a harmonic. It is the ratio of the frequency of a harmonic to the fundamental frequency of the signal.

3.2.12 Distortion factor (*d*)

The ratio of the r.m.s. value of the harmonic content (obtained e.g. by subtracting from a non-sinusoidal alternating quantity its fundamental term) to the r.m.s. value of the fundamental term. The distortion factor is usually expressed in percentage. It is equivalent to THD, total harmonic distortion.

3.2.13 Power factor (PF)

The ratio of the active power to the apparent power. At sinusoidal and one-phase, or symmetrical three-phase, conditions the power factor = $\cos\Phi$ = the cosine of the phase difference Φ between voltage *U* and current *I*.

3.2.14 Active power

The rate at which energy is transported. In an electrical system it is measured as the time mean of the instantaneous power, which is calculated at each instant as the product of voltage and current.

$$p(t) = u(t) \cdot i(t)$$

where:

u is the instantaneous voltage

i is the instantaneous current

p is the instantaneous power

At sinusoidal conditions active power is the product of the rms value of current and voltage and the cosine of the phase angle between them, calculated for each phase. It is usually expressed in kW.

$$P = U_{rms} * I_{rms} * \cos\Phi$$

3.2.15 Active energy

Active power integrated over time. Usually expressed in kWh or MWh

$$E(T) = \int_0^T p(t) \cdot dt = \int_0^T u(t) \cdot i(t) \cdot dt$$

where:

E is the active energy over the time. Other symbols are as defined in 3.2.14

3.2.16 Absolute error (of indication)

Indicated (energy) value minus the true (energy) value.

Note: Since the true value cannot be determined, it is approximated by a value with a stated uncertainty that can be traced to national standards.

3.2.17 Relative error (of indication)

Absolute error (of indication) divided by the true (energy) value, usually expressed as a percentage.

Note: Since this Recommendation deals only with relative error, the short form "error" is used for relative error.

3.2.18 Maximum permissible error (m.p.e.)

The extreme values of the relative error (of indication) of a meter, permitted by this Recommendation, while the meter is operated within the rated operating conditions. In this Recommendation, the maximum permissible error is given as Base maximum permissible error and Maximum permissible error shift. (VIM 5.21 modified)

3.2.19 Base maximum permissible error

The extreme values of the relative error (of indication) of a meter, permitted by this Recommendation, when the current and power factor is varied within the intervals given by the rated operating conditions, and when the meter otherwise is operated at reference conditions.

3.2.20 Maximum permissible error shift

The extreme values of the change in relative error (of indication) of a meter, permitted by this Recommendation, when a single influence factor is taken from its value at reference conditions and varied within the rated operating conditions. For each influence factor there is one corresponding maximum permissible error shift.

3.2.21 Intrinsic error

The error of a measuring instrument, determined under reference conditions. (VIM 5.24)

3.2.22 Initial intrinsic error

The intrinsic error of a measuring instrument as determined prior to performance tests and durability evaluations.

3.2.23 Influence quantity

A quantity that is not the measurand but that affects the result of the measurement. (VIM 2.7)

3.2.24 Influence factor

An influence quantity having a value within the rated operating conditions specified in this Recommendation. (OIML D11, modified)

3.2.25 Disturbance

An influence quantity having a value within limits specified in accordance with this Recommendation, but outside the specified rated operating conditions of the meter. (OIML D11, modified)

Note: An influence quantity is a disturbance if the rated operating conditions for that influence quantity are not specified.

3.2.26 Rated operating conditions

Conditions of use giving the range of values of influence quantities for which specified metrological characteristics of a measuring instrument are intended to lie within given limits. (VIM 5.5, modified)

3.2.27 Reference conditions

Conditions of use prescribed for testing the performance of a measuring instrument or for intercomparison of results of measurements. (VIM 5.7, modified)

Note: The reference conditions generally include reference values or reference ranges for the influence quantities affecting the measuring instrument.

3.2.28 Class index

A designation that identifies the set of base maximum permissible errors and maximum permissible error shifts that the meter shall comply with, and the set of permissible responses to disturbances that are allowed for the meter, as defined in this Recommendation.

3.2.29 Durability

Ability of a measuring instrument to maintain its performance characteristics over a period of use. (OIML D11)

3.2.30 Fault

The difference between the error of indication and the intrinsic error of a measuring instrument. (OIML D11, modified)

Notes:

(1) Principally, a fault is the result of an undesired change of data contained in or flowing through a measuring instrument.

(2) From the definition it follows that in this Document, a "fault" is a numerical value which is expressed either in a unit of measurement or as a relative value, for instance as a percentage.

3.2.31 Significant fault

A significant fault has occurred if the meter no longer meets the requirements on error stated in this Recommendation. (OIML D11, modified)

A significant fault has also occurred if a change larger than the critical change value has occurred in the measurement registers due to disturbances, or if the functionality of the meter has become impaired.

Faults that are detected and acted upon by means of a checking facility shall not be considered as significant faults.

3.2.32 Critical change value

Is the value at which the change in measurement result is considered undesirable. (Editor, alternative text: The maximum acceptable value of the change of the measurement result or error of measurement caused by a disturbance)

3.2.33 Checking facility

Facility that is incorporated in a measuring instrument and which enables significant faults to be detected and acted upon in such a way that incorrect registration is prohibited or recorded separately. (OIML D11, modified)

Note - The action should be either to stop measuring and record the time and duration of the stop, or record the time and duration of the significant fault and the amount of energy measured during the significant fault.

3.2.34 Metrologically sensitive components

Comprise all parts of software, hardware or firmware that contribute to the measurement of electric energy, and display or store the measurement results

3.2.35 Significant durability error

A sudden or gradual change of the metrological functionality of the meter such that a significant error occurs.

Specifcally significant durability error is:

a change in the measurement performance such that the relative error of measurement is higher than the maximum permissible error [1].

or a sudden change in the stored information that is of significance and do not originate in a energy passing through the meter.

or a change in the ability to handle disturbances such that the meter no longer fulfils the requirement of this Recommendation.

Note (1) - One such significant durability error is that the meter registers energy faster than given by the rated operating conditions.

4 Metrological Requirements

4.1 Rated operating conditions

Table 1. Rated operating conditions

Condition or influence quantity	Values, Ranges
Frequency	f_{nom} ±2 %, f_{nom} is to be specified by the manufacturer. If the manufacturer specifies more than one nominal frequency, the rated operating conditions shall be the combination of all f_{nom} ±2 % intervals
Voltage	U_{nom} ±10%, U_{nom} is to be specified by the manufacturer. If the manufacturer specifies more than one nominal voltage the rated operating conditions shall be the combination of all U_{nom} ±10 % intervals
Current	I_{st} to I_{max} I_{max} and I_{tr} to be specified by the manufacturer. The ratio I_{max}/I_{tr} must be equal to or higher than 50 for direct connected meters and equal to or higher than 24 for transformer operated meters. I_{min} = 0.5 I_{tr} for class A meters direct connected I_{min} = 0.4 I_{tr} for class A transformer operated meters and all class B meters, I_{min} = 0.2 I_{tr} for class C and D meters I_{st} = 0.05 I_{tr} for all class A I_{st} = 0.04 I_{tr} for all class B meters and for class C and D direct connected meters I_{st} = 0.02 I_{tr} for class C and D transformer operated meters
Power factor	From 0.5 inductive to 1 to 0.8 capacitive, except for classes C and D where operating range is from 0.5 inductive to 1 to 0.5 capacitive. For bi-directional meters the power factor range limits are valid in both directions
Temperature	From lower temperature limit to upper temperature limit as specified by manufacturer. The manufacturer shall specify the lower temperature limit from the values -55ºC, -40ºC, -25ºC, -10ºC, +5ºC. The manufacturer shall specify the upper temperature limit from the values +30ºC, +40ºC, +55ºC, +70ºC
Humidity and water	With respect to humidity, the manufacturer shall specify the environment class for which the instrument is intended: H1: enclosed locations where the instruments are not subjected to condensed water, precipitation, or ice formations; H2: enclosed locations where the instruments may be subjected to condensed water, water from sources other than rain and to ice formations; H3: open locations with average climatic conditions.
Connection modes	The manufacturer shall specify whether the meter is intended for direct connection, connection through current transformers or through current and voltage transformers. The manufacturer shall specify the connection mode, the number of measurement elements of the meter and the number of phases of the electric system for which the meter is intended. A watthour meter in accordance with this recommendation can be one of the following: - single-phase two-wire, 1 element; - single phase three-wire, 1 element (applicable only for balanced and symmetrical voltages) - single phase three-wire, 2 element - three-phase four-wire 3-element; - three-phase three-wire 2-element (applicable only in cases where leakage currents can be ruled out); - two-phase three-wire 2 element.(or a three phase meter operated as two-phase three-wire) The manufacturer may specify alternative connection modes for polyphase meters. These alternative connection mode(s) shall also be part(s) of the operating conditions.
Tilt	Mounting position as specified by the manufacturer ± 3 degrees. If no mounting position is given, any mounting position is allowed
Harmonics	The voltage and current shall be allowed to deviate from the sinusoidal form, as given by the requirements in clause 4.2.2, Table 4
Load balance	The load balance shall be allowed to vary from fully balanced conditions to current in only one current circuit for poly-phase meters and for single-phase 3-wire meters.

Note: Several of the values for rated operating conditions may be considered in legislation, see informative 9.4

4.2 Accuracy requirements

4.2.1 General

The manufacturer shall specify the class index of the meter, A, B, C or D.

Note - The class B is the lowest accuracy class recommended for large consumers, i.e. above 5000 kWh/year, or other value chosen by the appropriate authority.

The meter shall be designed and manufactured such that its error does not exceed the maximum permissible error for the specified class under rated operating conditions.

The meter shall be designed and manufactured such that, when exposed to disturbances, significant faults do not occur.

A fault is not considered a significant fault, if it is detected and acted upon by means of a checking facility. The meter shall clearly indicate such event. See 3.2.31 Significant fault and 3.2.33 Checking facility.

Note The indication could be a light flashing in the event of a fault.

4.2.2 Handling of the energy flow direction

Depending on how the manufacturer has declared the handling of energy flow direction, the meter shall correctly handle both positive and negative mean energy flow, where positive or negative energy flow shall be defined by the manufacturer's connection instructions for the meter. The mean energy flow refers to the active power integrated over at least one cycle of the nominal frequency. If the meter is declared to handle both energy flow directions, the meter shall fulfil the requirement of this Recommendation for both directions.

The handling of energy flow direction can be one of the following:

Single-register, bi-directional; where the meter is declared to measure both positive and negative mean flow of energy, and to place the net result in a single register.

Two-register, bi-directional; where the meter is declared to measure both positive and negative mean flow of energy, as defined by the connection of the meter, and to place the positive result and the negative result in different registers. For poly-phase meters the mean flow shall be over the sum of all phases.

Single-register, positive direction only; where the meter is declared to measure, and register, only positive mean energy flow. It may inherently, by its design, register only positive mean energy flow or it may be equipped with a reversal running detent. For poly-phase meters the mean flow shall be over the sum of all phases.

Single-register, uni-directional; where the meter is declared to measure, and register, the absolute value of the mean energy flow (Normally such that the meter will register all energy as consumed energy independent on the true direction of the energy flow or how the meter is connected) .

Note – For this purpose "single-register" and "two-register", refers to the basic energy register(s). For tariffs and other purposes the meter may have several other registers.

4.2.3 Maximum permissible errors at rated operating conditions

The relative error (expressed in percent) shall be within the base maximum permissible error stated in Table 2 when the current and power factor is varied within the limits given by Table 2, and when the meter otherwise is operated at reference conditions.

Table 2. Base maximum permissible error

Quantity	Base maximum permissible errors (%) for meters of class			
	A	B	C	D
Current I from I_{tr} to I_{max} and power factor variation from 0.8 cap to 1 to 0.5 ind,	±2.0	±1.0	±0.5[1]	±0.2[1]
Current I between I_{tr} and I_{min}, at unity power factor	±2.5	±1.5	±1.0	±0.4

Current I below I_{min}, at unity power factor [2]	Direct connected meter	$\pm2.5*I_{tr}/(2*I)$	$\pm1.5*I_{tr}/(2.5*I)$	$\pm1.0*I_{tr}/(5*I)$	$\pm0.4*I_{tr}/(5*I)$
	Transformer operated meter	$\pm2.5*I_{tr}/(2.5*I)$	$\pm1.5*I_{tr}/(2.5*I)$	$\pm1.0*I_{tr}/(5*I)$	$\pm0.4*I_{tr}/(5*I)$
No load [2]	No significant metered energy				

(1) – For this class the requirement is from power factor 0.5 ind. to 1 to 0.5 cap.

(2) – The meter is always allowed to stop for current below I_{st}.

The meter shall be able to carry I_{max} continuously without larger error than base maximum permissible error. Further, the error shift due to continuous current at I_{max} shall not be larger than 50% of the base maximum permissible error for the class.

Table 3. Limits for temperature coefficient of error

Influence Quantity	power factor	Limits for temperature coefficient (%/K) for meters of class			
		A	B	C	D
Temperature Coefficient (%/K), for any 15 K to 23 K interval within the temperature range, $I{\geq}I_{tr}$	1	±0.1	±0.05	±0.03	±0.01
	0.5 inductive	±0.15	±0.07	±0.05	±0.02

When the load current and power factor is held constant at a point within the rated operating range and with the meter otherwise operated at reference condition, and when any single influence factor is varied from its value at reference conditions to its extreme values, the variation of error shall be such that the additional percentage error is within the corresponding maximum permissible error shift stated in Table 4.

Table 4. Maximum permissible error shift due to influence factors

Influence Quantity	power factor	Maximum permissible error shift (%) for meters of class			
		A	B	C	D
Temperature, varied over entire specified temperature range, $I{\geq}I_{tr}$	1	±3.3	±1.7	±0.7	±0.3
	0.5 inductive				
Load balance, only for polyphase meters and for single phase 3-wire meters, current in only one current circuit, $I{\geq}I_{tr}$	1	±1.5[1]	±0.7	±0.2	±0.1
	0.5 inductive				
Voltage variation U_{nom} ±10%[2], $I{\geq}I_{tr}$	1	±1.0	±0.7	±0.2	±0.1
	0.5 inductive	±1.5	±1.0	±0.4	±0.2
Frequency variation f_{nom} ±2%, $I{\geq}I_{tr}$	1	±0.8	±0.5	±0.2	±0.1
	0.5 inductive	±1.5	±0.7	±0.2	±0.1
Harmonic components in voltage and current circuits (d is 0 – 40% I, 0 – 5% U)[3], $I{\geq}I_{tr}$	1	±1.0	±0.6	±0.3	±0.2
Tilt ≤3 degrees, $I{\geq}I_{tr}$	1	±1.5	±0.5	±0.4	n.a
Humidity as given by humidity class and test section	1	±0.2	±0.1	±0.05	±0.02

(1) A larger error shift is acceptable as long as the error is less than 2.5 %.

(2) For polyphase meters the requirement is for symmetrical voltage variations.

(3) As long as the RMS current is not higher than I_{max} and peak value of the current is not higher than 1.41*I_{max}. Further, the amplitude of individual harmonic components shall not exceed (I_1/h) for current and 0,12U_1/h for voltage, where h is the harmonic order.

4.2.4 Allowed effects of disturbances

4.2.4.1 General

The meter shall withstand the disturbances that it can be expected to be exposed to, as stated in the table below. No significant fault shall occur for any of the described disturbances. Each disturbance and its

value are only briefly defined in Table 5 and Table 6. The meter is considered to comply with the requirement of 4.2.1, that significant faults shall not occur, if it passes the corresponding test prescribed in chapter 7.

Due to the integrating nature of electricity meter, only influence factors that may prevail for relatively long times do affect the accuracy in a quantifiable way. The disturbances are therefore divided into these two categories, semi-steady state disturbances and disturbances of transient nature.

4.2.4.2 Semi-steady state disturbances

Table 5. Semi-steady state disturbances

All requirements are valid at power factor 1.0 and at 10 I_{tr}, unless otherwise specified. An error shift larger than prescribed below constitutes a significant fault.

Influence Quantity	Value	Limit of error shift (%), or allowed effects, for meters of class			
		A	**B**	**C**	**D**
Severe voltage variations	$0.8U_{nom} \leq U < 0,9\ U_{nom}$ $1.1U_{nom} < U \leq 1.15\ U_{nom}$	±1,5	±1	±0,7	±0,5
	$U < 0.8\ U_{nom}$	+10 to –100, shall function after			
One or two phase voltages interrupted[1]		±4	±2	±1	±0,5
Sub-harmonics in the AC current circuit	Two periods on – two periods off	±3	±1,5	±0,75	±0,5
Harmonics in the AC current circuit	I_{max}, phase-fired at 90 degrees	±1	±0.8	±0.5	±0,5
Reversed phase sequence	Any two phases interchanged	±1,5	±1,5	±0,1	±0,05
Continuous (DC) magnetic induction of external origin	≤ 200 mT[editors note] at 30 mm inside the cover	±3	±1,5	±0,75	±0,5
Magnetising field (AC, power frequency) of external origin.	≤ 300 A/m	±2.5	±1.3	±0,5	±0,25
Electromagnetic RF fields [2]	f=80 MHz to 800 MHz, f= 960 to 1400 MHz: ≤10 V/m, modulated f =800 to 960 MHz, 1400 to 2000 MHz: ≤30 V/m, modulated	±3	±2	±1	±1
Conducted disturbances induced by RF fields	F=0.15 MHz to 80 MHz: $U \leq 10$ V, modulated	±3	±2	±1	±1
DC in the AC current circuit [3]	sinusoidal current $I \leq I_{max}/\sqrt{2}$ half-wave rectified	±6	±3	±1.5	±1
High-order harmonics and interharmonics	2 % of fundamental voltage, f between 15 f_{nom} and 50 f_{nom}	±1	±1	±0,5	±0,5

(1) Only for polyphase meters. Two phases interrupted is only for those connections modes where a missing phase means that there can be no energy delivered.

(2) Direct or indirect, conducted disturbances induced by radio-frequency fields.

(3) Only for direct connected meters.

(editors note) modern magnets producing induction in excess of 100 mT at 25 mm have been used in known fraud attempts. This test level is designed to avoid the possibility to use magnets easily available for fraud purposes. This not will be removed later.

4.2.4.3 Critical change value for some disturbance tests

When the meter is operated under conditions described by Table 6 and when no current is applied, a change of the registers or pulses of the test output shall not be considered as a significant fault if the change of the registers or equivalent energy of the test output is less than:

Critical change value = $m * U_{nom} * I_{max} * 10^{-6}$ kWh,

where m is the number of measuring circuits.

4.2.4.4 Disturbances of transient nature

Table 6. Disturbances of transient nature

Disturbance quantity	Limit Value	Allowed effect
Magnetising field (AC, power frequency) of external origin.	1000 A/m, 3 s	No significant fault as given by the corresponding test
Electrostatic discharges	≤ 8 kV contact discharge, ≤ 15 kV air discharge As defined in the test section.	No significant fault as given by the corresponding test.
Fast transients	Voltage and current circuits: 4kV; auxiliary circuits: 2 kV, as defined in the test section.	No significant fault as given by the corresponding test.
All phase voltages interrupted	≤ 250 power line cycles. As defined in the test section	No significant fault as given by the corresponding test.
Voltage dips	≤ 60 % reductions, ≤ 50 power line cycles. As defined in the test section.	No significant fault as given by the corresponding test.
Voltage surges	Voltage circuits: ≤2kV line to line, ≤4kV line to earth. Ancillary circuits: ≤1kV line to line, ≤2kV line to earth. As defined in the test section.	No significant fault as given by the corresponding test.
Damped oscillatory waves[1]	Voltage circuits: Common mode ≤ 2,5 kV, differential mode ≤ 1,0 kV. As defined in the test section.	No significant fault as given by the corresponding test.
Short-time overcurrent	Direct connected meters: ≤30*I_{max}, meters connected through current transformers: ≤ 20*I_{max}. As defined in the test section.	No significant fault as given by the corresponding test.
Impulse voltage	According to Table 16 in test section	No significant fault: or other condition as given in the test section.
Earth fault[2]	Earth fault in one phase	No significant fault as given by the corresponding test.
Vibration	As defined in the test section.	No significant fault as given by the corresponding test.
Shock	As defined in the test section.	No significant fault as given by the corresponding test.
Extreme temperatures	As defined in the test section.	No significant fault as given by the corresponding test.
Humidity and water	As defined in the test section.	No significant fault as given by the corresponding test.

(1) Only for transformer operated meters.

(2) Only for three-phase four wire transformer-operated meters intended for use in networks equipped with earth fault neutralizers

Operation of auxiliary devices shall not be able to disturb the meter.

If no significant fault occurs during the appropriate test described in Part 2 of this Recommendation, the instrument is presumed to comply with the requirements of this sub-clause.

A significant fault is defined in clause 3.2.31.

4.3 Mechanical requirements

The meter shall withstand the amount of vibration and shock that it may be exposed to at normal use conditions, and as given by the corresponding tests.

Dust shall not impair the performance of the meter.

4.4 Name plate, markings

Every meter shall as minimum bear the following information:

Marking	Can alternatively be made visible on demand
Manufacturer	
Type	Yes
U_{nom}	

I_{max}	
I_{tr}	Yes
Temperature range	Yes
Humidity and water protection information	Yes
Impulse voltage protection information	Yes
Class index	Yes
Approval mark(s)	
Serial number	
Number of phases	
Number of wires	
f_{nom}	Yes
Register multiplier (if other than unity)	
Meter constant(s)	Yes
Year of manufacture	
The connection mode(s) for which the meter is specified	Yes
Meter directionality type	Yes

The markings shall be indelible, distinct and legible from outside the meter. The markings of meters intended for open locations shall withstand solar radiation.

If the serial number is affixed to dismountable parts, the serial number shall be provided also in a position where it is not readily disassociated from parts determining the metrological characteristics.

Symbols or equivalent may be used where appropriate. See e.g. IEC 62053-52, Electricity metering equipment (AC) - Particular requirements - Part 52: Symbols, or other designations accepted by local jurisdictions,

4.5 Protection of metrological properties

4.5.1 General provisions

Meters shall be provided with means to protect the metrological properties of the meter. The means can be mechanical or electronic or a combination.

All means to protect the metrological properties of the meters intended for open locations shall withstand solar radiation.

The meter shall have a case which, if dismountable, can be sealed and which can not be opened unintentionally. The internal parts of the meter shall be accessible only by such means that results in permanently visible damage to the seal or case. It shall be possible to install or disconnect the meter without breaking the seal that protects the internal parts of the meter.

Software resident in the meter (firmware) must be uniquely identified.

Software that affects the metrological characteristics shall be identified as such and shall be secured. Software identification shall be provided and evidence of an intervention shall be available for at least 12 months after the meter has been de-energised.

4.5.2 Protection of hardware and firmware

Any metering hardware or firmware shall be protected in such way that it is impossible to change without breaking a seal as described above or otherwise leave permanent evidence of the change in the meter or its software.

Parameters that participate in the determination of results of measurement shall be protected, by mechanical seals or by other means. In case of non-mechanical protection, it shall fulfil the following provisions:

a) Any change of the software itself or the metering parameters may not be completed without authorised access, for example by means of a code (password) or of a special device (hard key, etc.).

b) Access to parameters that participate in the determination of results of measurement and access to other parameters that is not directly used for metering shall have separate authorisation, such that e.g. installation of the meter is possible without giving installation personnel access to the software or the metering parameters.

c) The register that stores the total energy metered may not be changed or zeroed without authorised access, for example by means of a code (password) or of a special device (hard key, etc.). The password shall only be acceptable if it is provided by a dedicated device that allows to add an encrypted signature.

d) The means for authorized access shall be updatedable.

e) If the metrological integrity of a meter cannot be maintained during the parameter change process, the meter shall stop registering energy until the modifications are completed.

f) If it is possible to change parameters or the register that store the total energy metered, it shall be possible to record all interventions. For identification, data concerning the latest intervention shall be recorded into an event logger. The record shall include at least an event counter, the date the parameter was changed, and the old and new value of the parameter. If the event logger capacity is reached, the meter shall not allow any further changes to be made which effect parameters until the event log data has been transferred to a secure storage facility. The meter shall maintain the integrity of any event logger data for the entire period that the meter has a valid seal or until the event log data has been transferred.

4.6 Suitability for use

4.6.1 Readability of result

The indicating device shall be easy to read and the characters of measurement results shall as minimum be 4 mm high. Any decimal fractions shall be clearly indicated. For mechanical registers, any decimal fraction drum shall be marked differently.

The indicating device of meters intended for open locations shall withstand solar radiation.

In the case of multiple values presented by a single indicating device it shall be possible to display the content of all relevant memories. For automatic sequencing displays, each display of register for billing purposes shall be retained for a minimum of 5 s.

For multi-tariff meters, the register which reflects the active tariff shall be indicated. It shall be possible to read each tariff register locally and each register shall be clearly identified.

The register shall be capable to store and display an energy amount that corresponds to the meter running at $P = U_{nom} \cdot I_{max} \cdot n$ for at least 4000 h, where n is the number of phases.

Note: The National Authority may change the minimum time for the register roll over

In the case of electronic registers, the minimum retention time of results is one year for a disconnected meter.

4.6.2 Testability

The meter shall be equipped with a test output for efficient testing, such as a rotor with a mark or a test pulse output. If the design of the test output is such that the pulse rate does not correspond to the measured power in every given relevant time interval, the manufacturer shall declare the necessary number of pulses to ensure a standard deviation of measurement less than 0,1 base mpe, at I_{max}, I_{tr}, I_{min}

The relation between the measured energy given by the test output and the measured energy given by the indicating device shall comply with the marking on the name-plate.

4.6.3 Checking facility

If the meter is equipped with a checking facility, the event record of the facility shall have room for at least 100 events and shall be of first-in-first-out type. The event record may not be changed or zeroed without breaking seals or without authorised access, for example by means of a code (password) or of a special device (hard key, etc.).

4.7 Durability

4.7.1 Reliability and durability requirement

The meter shall be designed to maintain an adequate stability of its metrological characteristics over a period of time specified by the manufacturer, provided that it is properly installed, maintained and used according to the manufacturer's instructions when in the environmental conditions for which it is intended.

A measuring instrument shall be designed to reduce as far as possible the effect of a defect that would lead to an inaccurate measurement result, unless the presence of such a defect is obvious.

The meter shall be designed and manufactured such that either

a) Significant durability errors do not occur, or

b) Significant durability errors are detected and acted upon by means of a durability protection.

The manufacturer shall provide documentation for the durability of the meter.
This can be accomplished by different means at the choice of the manufacturer:

c) Description of design measures for durability enhancement or protection

d) Through documented experiences from operation of meters of similar construction and/or;

e) Through durability tests. The durability test shall be described by the manufacturer. It shall as far as possible relate to international standards and general accepted procedures.

Note - Manufacturers data on durability is useful for national legislation regarding intervals for subsequent verifications and/or statistical sampling schemes.

Part 2 Tests

5 Type approval

5.1 Documentation

The documentation submitted with the application for type approval shall include:

a) Identification of the type, including

   1) name or trademark and type designation

   2) Version(s) of hardware and software

   3) drawing of name plate

b) Metrological characteristics of the meter, including

   1) a description of the measuring principle

   2) the metrological specification for the meter

   3) adjustment description, where applicable

c) The technical specification for the meter, including

   1) a block diagram with a functional description of the components and devices,

   2) drawings, diagrams and general software information, explaining the construction and operation, including interlocks,

   3) description and position of seals or other means of protection,

   4) documentation related to durability characteristics,

   5) any document or other evidence that the design and construction of the meter complies with the requirements of this recommendation.

d) User manual.

e) Installation manual

f) A description of the checking facility for significant faults, if applicable.

Furthermore, if the type approval is to be based on existing type test documentation, the application for type approval shall be accompanied by type test documents or other evidence that supports the assumption that the design and characteristics of the measuring instrument comply with the requirements of this Recommendation.

5.2 Type definition

Meters, produced by the same manufacturer, may form a type provided they have similar metrological properties by the use of the same uniform construction of parts/modules that determines the metrological properties.

A type may have several current ranges and several values of the nominal voltage and frequency, and include several connection modes and several ancillary devices.

Note: The same uniform construction normally means the same construction of the measuring elements, the same construction of metering software, the same construction of the register and indicating device, the same temperature compensation mechanism, the same construction of case, terminal block, and mechanical interface.

5.2.1 Type test sampling

The manufacturer shall provide at least three specimens of the meter. The type test shall be made on one or more specimens of the meter, selected by the type test body, to establish its specific characteristics and to prove its conformity with the requirements of this Recommendation. In the case of modifications to the meter made after or during the type test and affecting only part of the meter, the issuing body may deem it sufficient to perform limited tests on the characteristics that may be affected by the modifications.

6 Test program

The initial intrinsic error shall be determined as the first test on the meter, as described in 7.2.1.

During the test for initial intrinsic error the meter shall be allowed to stabilize during 1 – 5 minutes on each current level before measurements. The order of the testpoints shall be from lowest current to the highest current and then from highest current to lowest current. For each testpoint, the resulting error shall be the mean of these measurements. For I_{max}, the maximum measurement time shall be 10 minutes including stabilizing time.

The determination of the intrinsic error (at reference conditions) shall always be carried out before tests of influence factors and before disturbance tests that relate to a maximum permissible error shift requirement or to a significant fault condition for error.

Otherwise the order of tests is not prescribed in this Recommendation.

Test (pulse) outputs may be used for tests of accuracy requirements. A test must then be made to ensure that the relation between the basic energy register and the used test output complies with the manufacturers specification.

If a meter is specified with alternate connections modes, such as one-phase connection of polyphase meters, the tests for base maximum permissible error in accordance with 4.2.3 shall be made for all specified connection modes, at minimum.

7 Test procedures for type approval

7.1 Test conditions

Unless otherwise stated in the individual test instructions, all influence quantities, except for the influence quantity being tested, shall be held at reference conditions as given by Table 7 during type approval tests.

Table 7 Reference conditions and their tolerances

Quantity	Reference conditions	Tolerance
Voltage(s) [2]	U_{nom}	± 1 %
Ambient temperature	23º C[1]	± 2ºC
Frequency	f_{nom}	± 0.3 %
Wave-form	Sinusoidal	d ≤ 2 %
Magnetic induction of external origin at reference frequency	0 T	B ≤ 0.05 mT
Electromagnetic RF fields 150 kHz- 2GHz	0 V/m	≤ 1 V/m
Operating position for instruments sensitive to position	Mounting as stated by manufacturer	± 0.5 º
Phase sequence for polyphase meters	L1, L2, L3	-
Load balance	Equal current in all current circuits	± 2 % and ± 2 º

[1] Tests may be performed at other temperatures if the results are corrected to the reference temperature by applying the temperature coefficient established in the type tests, and provided appropriate uncertainty analysis is carried out.

[2] The requirement applies to both phase-to-phase and phase-neutral for polyphase meters

Note – The reference conditions and their tolerance are given to ensure reproducibility between testing laboratories, not to determine the accuracy of the tests! The demands on short time stability during test for influence factors may be much higher than shown in this table.

Table 8. Load conditions and their tolerances in tests

Quantity	Conditions	Tolerance
Current(s)	Current range of device under test	Class A,B: ± 2 % Class C,D: ± 1 %

Power factor	Power factor range of device under test	current to voltage phase difference ± 2 °

Note – The load conditions and their tolerance are given to ensure reproducibility between testing laboratories, not to determine the accuracy of the tests! The demands on short time stability during test for influence factors may be much higher than shown in this table.

For most tests, keeping the influence quantities constant at reference conditions means that the measured power will be constant. However, for some tests such as for influence of voltage variation and load unbalance this is not possible. Therefore, the error shift shall always be measured as the shift of the relative error and not of the absolute power.

7.2 Tests for maximum permissible error

7.2.1 Determination of initial intrinsic error

It shall be tested that the error of the meter, at reference conditions, is less than stated in Table 2. Base maximum permissible error . Mandatory testpoints:

Table 9. Mandatory testpoints for base maximum permissible error test.

Current	Most inductive power factor[1]	Unity Power factor	Most capacitive power factor[1]
I_{min}		Yes	
I_{tr}	Yes	Yes	Yes
$2\,I_{tr}$	Yes	Yes	
$10\,I_{tr}$	Yes	Yes	Yes
$0.5\,I_{max}$		Yes	
I_{max}	Yes	Yes	

[1] Most inductive or capacitive power factor according to Table 1

Note – If results at inductive test points differ significantly in magnitude from corresponding test points on capacitive testpoints, further tests on other capacitive test points should be considered

Meters that are declared to measure both positive and negative mean flow of energy as described in 4.2.2 shall be tested for both directions. Mandatory testpoints for negative flow are I_{tr} and I_{max} as given by Table 9.

Meters that are declared <u>not</u> to measure both positive and negative mean flow of energy as described in 4.2.2 shall be subjected to reversed energy flow. The meter shall not register energy in the primary register or emit more than one pulse from the test output. The test time shall be at least 1 minute, or the time that the test output would register ten pulses in the forward energy flow direction, or the time that the primary register would register 2 units of the least significant digit in the forward energy flow direction, whichever is longest. Mandatory testpoints are I_{min} and I_{max} at power unity factor.

For reverse running detent designs that are prone to be affected by heating the test time shall be extended to 10 minutes at I_{max}.

7.2.2 Continuous maximum current

It shall be tested that the meter is able to carry I_{max} continuously as specified in 4.2.3. The test shall be carried out as follows: With the meter otherwise at reference conditions, the maximum current shall be applied to the current circuits. The cable to be used for energizing the meter shall be of copper, have a length of 1 m and a cross-section to ensure that the current density is between 3,2 A/mm^2 and 4 A/mm^2.

The error of the meter shall be monitored at unity power factor and at intervals short enough to record the curve of error variation as a function of time. The test shall be carried out for at least 1 h, and in any event until the variation of error during 20 min does not exceed 10 % of base maximum permissible error. The error of the meter and the error shift compared to the intrinsic error shall comply with requirements given in 4.2.3 at all times.

If the maximum error shift does not occur at the end of the test, the meter shall be allowed to return to its initial temperature and the test shall be repeated at power factor = 0,5 inductive. Otherwise, with minimum

interruptions for changing measurement point, the error of the meter shall also be measured, at I_{max} and power factor = 0,5 inductive, and it shall be checked that the error of the meter and the error shift compared to the intrinsic error comply with requirements given in 4.2.3.

7.2.3 Starting current

The meter shall be subjected to a current equal to the starting current I_{st}. It shall be tested that the meter starts and continues to operate at this current as given by Table 1.

If the meter is designed for the measurement of energy in both directions, then this test shall be applied with energy flowing in each direction. The effect of intentional delay of metering after reversal of energy direction should be taken into account when performing the test.

The meter shall be considered to have started if the output produces pulses (or revolutions) at a rate consistent with the base maximum permissible error requirements given by Table 2.

Mandatory test points: I_{st} at unity power factor.

7.2.4 Test of no-load condition

This is to test the required no-load performance of the meter given by Table 2. For this test, the current in the current circuit shall be 0.2 I_{st} at unity power factor.

For meters with test output, the output of the meter shall not produce more than one pulse. For an electromechanical meter, the rotor of the meter shall not make a complete revolution.

The test period Δt shall be

$$\Delta t \geq \frac{75 \cdot 10^3}{k \cdot m \cdot U_{nom} \cdot 0.2 I_{st}} \text{ minutes}.$$

k is the number of pulses emitted by the output device of the meter per kilowatthour (imp/kWh) or number of revolutions;

m is the number of measuring elements;

U_{nom} is the nominal voltage in volts;

I_{st} is the starting current in amperes.

For transformer-operated meters with primary or half-primary registers where the value of k (and possibly U_n) are given as primary side values, the constant k (and U_{nom}) shall be recalculated to correspond to secondary side values (of voltage and current).

7.2.5 Meter constants

If test (pulse) outputs are used for tests of accuracy requirements, a test must be made to ensure that the relation between the basic energy register and the used test output(s) complies with the manufacturers specification as required in 4.6.2.

All registers and pulse outputs that are under legal control must be tested unless a system is in place that guarantees identical behaviour of all meter constants.

The test shall be made by putting the energy E through the meter, where E is at least:

$$E_{min} = \frac{R \cdot 10 \cdot 100\%}{\text{base maximum permissible error}(\%)}$$

where *R* is the resolution of the basic energy register. The relative difference between the registered

energy and the energy passed through the meter as given by the number of pulses from the test output shall be computed. The relative difference must not be greater than equivalent to one tenth of the base maximum permissible error. The test may be performed at one arbitrary current $I \geq I_{tr}$.

Note: Any means may be used to enhance the resolution R of the basic register, as long as care is taken to assure that the results reflect the true resolution of the basic register.

7.2.6

7.2.7 Influence factors

7.2.7.1 General

During these tests it shall be checked that the error shift due to the variation of influence factors is within the maximum permissible error shift stated in Table 4. (See also the definition of maximum permissible error shift in 3.2.20)

7.2.7.2 Temperature dependence.

This is to verify that the requirements for temperature coefficient of Table 3 and the error shift requirement of Table 4 are fulfilled. For each testpoint, the error of the meter shall be determined at reference temperature and at each of the upper and lower ambient temperature limits, given by Table 1. Rated operating conditions, for which the meter is specified.

The error shift compared to the intrinsic error, at 23 degrees Celsius, shall be computed for each of the above temperatures and must comply with the requirement of Table 4.

Further, for each testpoint and for each temperature interval given by adjacent upper or lower temperature limits, including the reference temperature, the (mean) temperature coefficient, c, shall be determined as:

$$c = \frac{e_u - e_l}{t_u - t_l}$$

e_u and e_l are the error at the uppermost and the lowest temperature respectively in the temperature interval of interest.

t_u and t_l are the uppermost and the lowest temperature respectively in the temperature interval of interest.

Each temperature coefficient must be in accordance with the requirement of Table 3. Limits for temperature coefficient .

Mandatory testpoints: The test shall at minimum be performed at PF = 1 and PF= 0.5 and for currents of I_{tr}, 10 I_{tr} and I_{max}

7.2.7.3 Load balance

This test is only for polyphase meters and for single-phase three-wire meters. The error of the meter with current in one current circuit only shall be measured and compared to the intrinsic error, at balanced load. The error shift may not be larger than stated in Table 4. During the test reference voltages shall be applied to all voltage circuits.

Mandatory testpoints: The test shall be performed for all current circuits and at PF = 1and PF = 0.5ind. and at minimum for currents of 10 I_{tr} and I_{max} for direct connected meters and at minimum at I_{max} for transformer operated meters.

7.2.7.4 Voltage variation

The error shift, compared to the intrinsic error, at U_{nom}, shall be measured when the voltage is varied within the corresponding rated operating range. For polyphase meters, the test voltage shall be balanced.

The error shift may not be larger than stated in Table 4. If several U_{nom} values are stated, the test shall be repeated for each U_{nom} value.

Mandatory testpoints: The test shall be performed at 10 I_{tr}, PF = 1and PF = 0.5 inductive and at voltages 0.9 U_{nom} and 1.1 U_{nom}.

7.2.7.5 Frequency requirements

The error shift, compared to the intrinsic error, at f_{nom}, shall be measured when the frequency is varied within the corresponding rated operating range. The error shift may not be larger than stated in Table 4. If several f_{nom} values are stated, the test shall be repeated with each f_{nom} value.

Mandatory testpoints: The test shall be performed at 10 I_{tr}, PF = 1 and PF = 0.5 ind. and at minimum for frequencies of 0.98 f_{nom} and 1.02 f_{nom}.

7.2.7.6 Harmonics in voltage and current

The error shift, compared to the intrinsic error, at sinusoidal conditions, shall be measured when harmonics are added in both the voltage and the current. The error shift due to harmonics shall not be larger than stated in Table 4. The amplitude of a single harmonic should not be more than 0,12 U_1/h for voltage and I_1/h for the current, where h is the harmonic number an I_1 is the fundamental. The peak value of the current may not exceed 1.4 I_{max}., i.e. for the second table the fundamental current I_1 may not exceed 0.58 I_{max} The rms current may not exceed I_{max}, i.e. the fundamental current component I_1 may not exceed 0.93 I_{max}.

Mandatory testpoints: The test shall as a minimum be performed at 10 I_{tr}, PF = 1 and PF = 0.5 inductive with power factor given for the fundamental component. The harmonics shall be according to the tables below:

Table 10. Quadriform waveform

Harmonic number	Current amplitude	Current phase angle	Voltage amplitude	Voltage phase angle
1	100 %	0 °	100 %	0 °
3	30 %	0 °	3.8 %	180 °
5	18 %	0 °	2.4 %	180 °
7	15 %	0 °	1.7 %	180 °
11	10 %	0 °	1.1 %	180 °
13	5 %	0 °	0.8 %	180 °

Table 11. Peaked wave

Harmonic number	Current amplitude	Current phase angle	Voltage amplitude	Voltage phase angle
1	100 %	0 °	100 %	0 °
3	30 %	180 °	3.8 %	0 °
5	18 %	0 °	2.4 %	180 °
7	15 %	180 °	1.7 %	0 °
11	10 %	180 °	1.1 %	0 °
13	5 %	0 °	0.8 %	180 °

Harmonic amplitudes are calculated relative the amplitude of the fundamental frequency component of the voltage or current respectively. Phase angle is calculated relative the zero-crossing of the fundamental frequency voltage or current component respectively.

7.2.7.7 Tilt

This test is only for electromechanical meters or meters of other constructions that may be influenced by the working position. The error shift, compared to the intrinsic error, at the operating position given by the

manufacturer, shall be measured when meter is tilted from its ideal position to an angle 3 degree from that position. The error shift shall comply with the requirements of Table 4.

Mandatory testpoints: The test shall as minimum be performed at I_{tr}, PF = 1 and at two perpendicular tilting angles.

7.3 Test for disturbances

7.3.1 Semi steady-state disturbances

7.3.1.1 General

During these tests it shall be checked that the error shift due to influence factors does not exceed the critical change value or that it is within the maximum permissible error shift stated in Table 5. (See also the definition 3.2.31, Significant fault)

7.3.1.2 Severe voltage variations

This is to verify the provisions for the influence of severe voltages variations of Table 5. The error shift, compared to the intrinsic error, at U_{nom}, shall be measured and it shall be verified that the error shift complies with the requirements of Table 5 when the voltage is varied from 0.8 U_{nom} to 0.9 U_{nom} and from 1.1 U_{nom} to 1.15 U_{nom}. For polyphase meters, the test voltage shall be balanced. If several U_{nom} values are stated, the test shall be repeated for each U_{nom} value.

Mandatory testpoints: The test shall as minimum be performed at 10 I_{tr}, PF = 1 and for voltages of 0.8 U_{nom}, 0.85 U_{nom}, 1.10 U_{nom} and 1.15 U_{nom}.

Further, the error shift, compared to the intrinsic error, at U_{nom}, shall be measured when the voltage is varied from 0.8 U_{nom} down to 0 and compared to the requirements of Table 5.

Mandatory testpoints: The test shall as minimum be performed at 10 I_{tr}, PF = 1 and for voltages of 0.70 U_{nom}, 0.6 U_{nom}, 0.50 U_{nom}, 0.40 U_{nom}, 0.30 U_{nom}, 0.20 U_{nom}, 0.10 U_{nom}, 0 V. If the meter has a distinct shut-down voltage, this point shall instead be found and one testpoint within 2 V below that voltage shall be tested. In this case a test point within 2 V above the turn-on voltage shall also be tested.

7.3.1.3 One or two phase voltages interrupted

This is to verify the provisions for the influence of one or two phase voltages interrupted of Table 5. The test is only for polyphase meters with three measuring elements. The error shift, compared to the intrinsic error, at balanced voltage and load current conditions, shall be measured when one or two of the phase voltages are removed, while keeping the load current constant.

Mandatory testpoint: I=10Itr, two of the phase voltages removed in combinations such that each phase has been removed at least once.

7.3.1.4 Sub-harmonics in the AC current circuit

This is to verify that the meter fulfils the requirements for the influence of sub-harmonics of Table 5. The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured when the sinusoidal reference current is replaced by another sinusoidal signal with twice the peak value, and which is switched on and off every second period as shown by Figure 1 a) and b) (The measured power should then be the same as for the original sinusoidal signal while the rms current is 1.41 times higher). Care should be taken that no significant DC current is introduced. During the test, the peak value of the current may not exceed 1.4 I_{max}. The error shift shall be compared to the requirements of Table 5. Mandatory testpoints: The test shall as minimum be performed at a reference current of 10 I_{tr}, PF = 1.
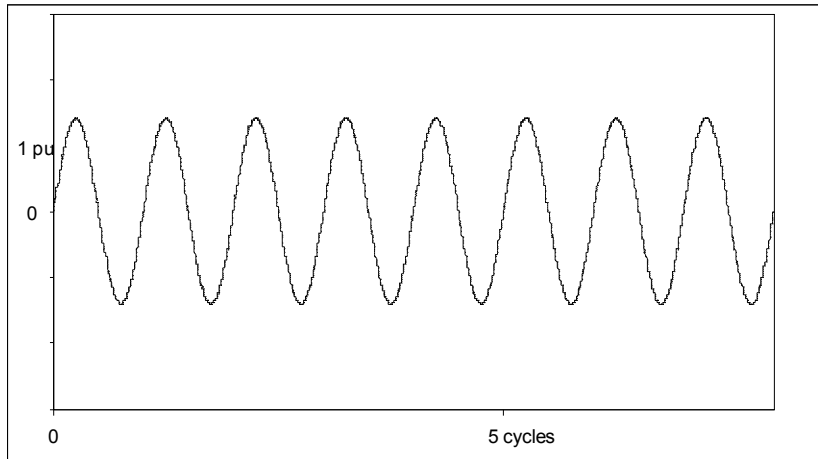
a) Test current for intrinsic error
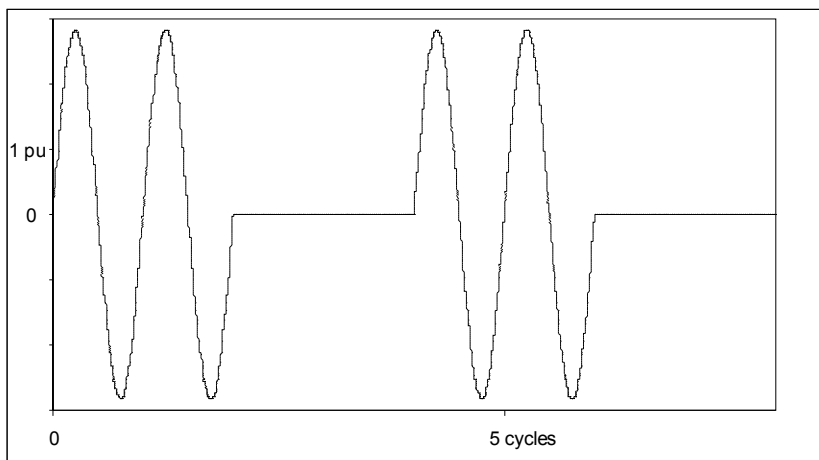
b) sub-harmonic test current
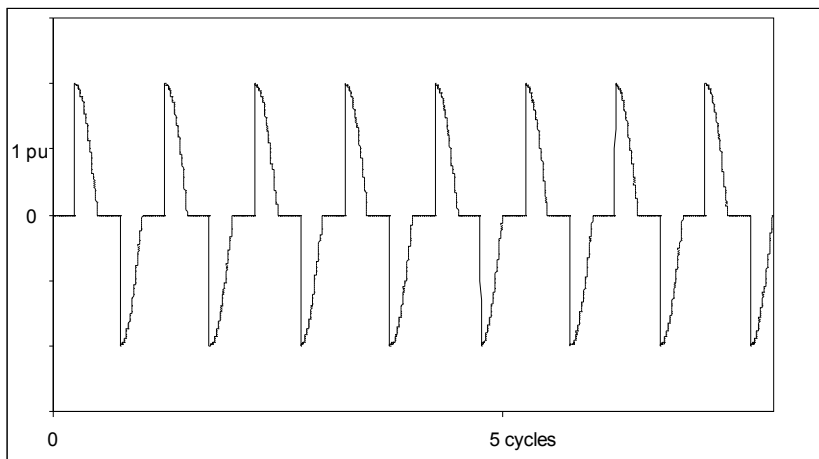
c) Harmonics test current

Figure 1. Test currents for sub-harmonics and harmonics tests.

7.3.1.5Harmonics in the AC current circuit

This is to verify that the meter fulfils the requirements for the influence of harmonics in the current as given by Table 5. The error shift, compared to the intrinsic error, at sinusoidal conditions, shall be

measured when the sinusoidal reference current is replaced by a current of twice the peak value where the sinusoidal waveform has been set to zero for the first and third quarter of the period as shown by Figure 1 a) and c) (The measured power should then be the same as for the original sinusoidal signal while the rms current is 1.41 times higher). During the test, the peak value of the current may not exceed 1.4 I_{max}. The error shift shall be compared to the requirements of Table 5. The test shall otherwise be performed at reference conditions.

Mandatory testpoints: The test shall as minimum be performed at a reference current of 10 I_{tr}, PF=1.

7.3.1.6 Reversed phase sequence (any two phases interchanged)

This test only applies for three-phase meters. The error shift, compared to the intrinsic error at reference conditions, shall be measured and compared to the requirements of Table 5, when any two of the three phases are interchanged.

Mandatory testpoints: The test shall as minimum be performed at 10 I_{tr}, PF = 1 with any two of the three phases are interchanged.

7.3.1.7 Continuous (DC) magnetic induction of external origin

This is to verify that the meter fulfils the requirements for influence of continuous (DC) magnetic induction of Table 5. The error shift, compared to the intrinsic error, at reference conditions, shall be measured when a probe in the form of a permanent magnet with at least a surface area of 2000 mm². The magnetic field at the core axis shall comply with Table 12 below.

Mandatory testpoints: 6 points per surface. If the meter is intended for wall mounting the back surface does not have to be tested. The applied current test point should be 10 I_{tr}, PF =1. The greatest error shift is to be noted as the test result.

Table 12. Field at axis at different distances form the core surface

Distance from core surface	Magnetic induction	Tolerance
30 mm	200 mT	±30 mT

Neodym or niobium permanent magnets are suggested for this test.

7.3.1.8 Magnetising field (AC, power frequency) of external origin.

Applicable standard IEC 61000-4-8.

This is to verify the provisions for the influence of magnetising fields (AC power frequency) of Table 5. The error shift, compared to the intrinsic error at reference conditions, shall be measured when the meter is subjected to an ac magnetising field at power frequency.

Test procedure in brief: The test consists of exposure to power frequency magnetic field ($f=f_{nom}$). During the test the error shift must not be larger than indicated in Table 5.

Test severity: Continuous field, 300 A/m

Mandatory testpoints: The test shall as minimum be performed at 10 I_{tr} and at I_{max}, PF = 1 and with the magnetising field in three perpendicular angles.

7.3.1.9 Electromagnetic fields

7.3.1.9.1 Radiated, radio frequency(RF), electromagnetic fields

Applicable standard IEC 61000-4-3.

The error shift, compared to the intrinsic error, at sinusoidal conditions, shall be measured when the meter is subjected to electromagnetic RF fields. This is to verify that the meter fulfils the requirements for influence of RF fields of Table 5.

Test procedure in brief: The equipment under test (EUT) shall be exposed to electromagnetic field strength as specified by the severity level and a field uniformity as defined by the referred standard. The frequency ranges to be considered are swept with the modulated signal, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value. The test time for a 1 % frequency change shall not be less than the time to make a measurement and in any case not less than 0,5 s.

The EUT shall be tested as a table top instrument. During the test, the EUT shall be energized with reference voltage and a current equal to 10 I_{tr}. The measurement error of the EUT shall be monitored by comparison with a reference meter not exposed to the electromagnetic field or immune to the field or by an equally suitable method. The measurement time compared to the sweep time shall be such, or the dwell time of the amplitude modulated carrier at each frequency shall be such, that the error at each 1% incremental interval of the carrier frequency is monitored and can be compared to the requirements of Table 5.

Editor: Alternative text of last sentence: , The error at each 1% incremental interval of the carrier frequency shal be monitored and compared to the requirements of Table 5. When using a continuous frequency sweep this can be accomplished by adjusting ratio of the sweep time and time of each measurement. When using incremental 1% frequency steps is can be done by adjusting the dwell time on each frequency to fit the measurement time.

The cable length exposed to the electromagnetic field shall be 1m.

The carrier shall be modulated with 80 % AM at 1 kHz sine wave.

The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately[1].

Note (1) Usually, these sensitive frequencies can be expected to be the frequencies emitted by the EUT.

Meters constructed with passive elements only, as for example electromechanical meters, may be regarded as immune to radiated radio frequency fields.

Table 13. Severity of test

Frequency range	Field strength
80 – 800 MHz	10 V/m
960 – 1400 MHz	10 V/m
800 – 960 MHz	30 V/m
1400 – 2000 MHz	30 V/m

7.3.1.9.2 Conducted radio-frequency fields

Applicable standard IEC 61000-4-6.

This is to verify that the meter fulfils the requirements for influence of conducted RF fields of Table 5. Test procedure in brief: Radio frequency electromagnetic current, simulating the influence of electromagnetic fields shall be coupled or injected into the power ports and I/O ports of the EUT using coupling/decoupling devices as defined in the referred standard. The performance of the test equipment consisting of an RF generator, (de-)coupling devices, attenuators, etc. shall be verified.

The EUT shall be tested as a tabletop instrument. During the test, the EUT shall be energized with reference voltage and a current equal to 10 I_{tr}. The measurement error of the EUT shall be monitored. The measurement time compared to the sweep time shall be such, or the dwell time of the amplitude modulated carrier at each frequency shall be such, that the error at each 1% incremental interval of the carrier frequency is monitored and can be compared to the requirements of Table 5.

If the EUT is a polyphase meter, the tests shall be performed at all extremities of the cable.

Meters constructed with passive elements only, as for example electromechanical meters, may be regarded as immune to conducted radio interference.

Test severity:

RF amplitude (50 Ohm): 10 V (e.m.f.)

Frequency range : 0,15 – 80 MHz

Modulation: 80 % AM, 1 kHz sine wave

7.3.1.10DC in the AC current circuit

The error shift, compared to the intrinsic error, at sinusoidal conditions, shall be less than the requirements of Table 5 when the amplitude is increased to twice its value and the current is half-wave rectified.

The test is not applicable to transformer operated meters.

The test shall be performed at $I = I_{max}/\sqrt{2}$, PF = 1, where I is the current through the standard meter.

Note: The half-wave rectification and measurement can be done as shown by Figure 2, (only the current path is shown, the voltage shall be connected as normal). The uncertainty of measurement in this method is very dependent on the (sub-period) output impedance of the current source and the current circuit impedance of the standard meter in combination with the possible impedance differences of the two current branches. N.B! Since the uncertainty is dependent on the absolute branch impedance difference and not the relative(if not $R_{balancing}$ >> R_{source}), the problem can generally not be remedied by introducing additional matched resistors in each branch. It can, however, be monitored by studying the dc current from the source. The dc components should not be higher than 0.5 to 1 % of the ac value.(When measuring a DC component in the order of one percent of the AC component, the instrument should preferably be calibrated beforehand, by a measurement on the test current with the test circuit diodes disconnected and short-circuited.)
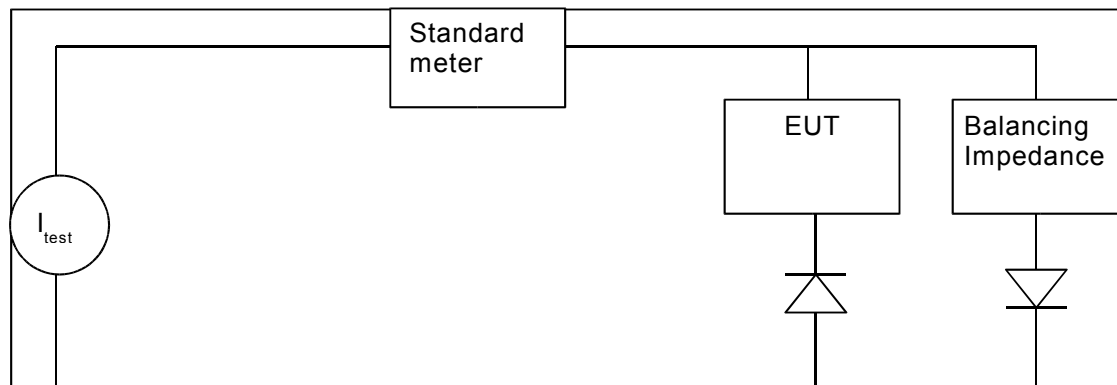
Figure 2. Proposed current test circuit for DC and even harmonic test (only one-phase current circuit shown, voltage to be connected as normal)

7.3.1.11High order harmonics.

This is to verify the provisions for the influence of high order harmonics of Table 5.

Test Procedure: Asynchronous test signals, swept from f = 20*f_{nom} to 50 *f_{nom}, shall be superimposed first on the signal to the voltage circuits and then on the signal to the current circuits. For a poly-phase meter it is allowed to test all voltage or current circuits at the same time. The function of the meter shall not be impaired and the additional error shall not exceed the additional error stated in Table 5 The signal frequency shall be swept from low frequency to high frequency and back down while the metering error is measured.

Severity: The asynchronous signal shall have a value of 0.01*U_{nom} and 0.1 I_{tr} respectively, with a tolerance of ±5%.

Mandatory testpoints: The meter shall be operated at reference conditions with a current equal to I_{tr} . The test the sweep time shall be adjusted so that at least 100 accurate reading of the meter error is made during each sweep.

Note: The error of the meter can e.g. be plotted on a strip chart recorder or stored to a file.

7.3.2 Disturbances of transient nature

7.3.2.1 General instructions for disturbance tests

These tests are to verify that the meter fulfils the requirement for the influence of disturbances of transient nature as given by Table 6. One disturbance at the time shall be tested, with all other influence quantities set to the reference conditions if nothing else is stated in the test descriptions. No significant fault, as defined in chapter 3 Terminology, shall occur. If nothing else is stated the test for significant fault shall include:

a) a check that the registers are not affected more than the critical change value given in 4.2.4.3,

b) an operational check, i.e. to verify that the meter registers energy when subjected to current,

c) a check for correct operation of pulse outputs and tariff change inputs, if present,

d) and a test that the meter still fulfil the base maximum permissible error requirements after the test.

e) Temporary loss of functionality is allowed as long as the meter returns to normal functionality automatically when the disturbance is removed.

f) The mandatory testpoints for the check of base maximum permissible error are at:

1) Itr, PF=1,

2) 10 Itr, PF=0,5 ind.

7.3.2.2 Magnetising field

IEC publication 61000-4-8 shall be applied for this test.

Test procedure in brief: The test consists of exposure to power frequency magnetic field to verify the provisions for Magnetic induction (AC, power frequency) of external origin given by 4.2.4.2, Table 6Table 5 .

The meter shall be connected to reference voltage but with no current in the current circuits. The magnetic induction shall be applied in three perpendicular angles. During the test no significant fault shall occur.

Test severity: Magnetic field strength short duration (1 s to 3 s):1000 A/m

7.3.2.3 Electrostatic discharge

Applicable standard IEC 61000-4-2.

Object of the test: to verify compliance to requirements in 4.2.4.4, Table 6 under conditions of electrostatic discharge.

Test procedure in brief: An ESD generator shall be used with a performance as defined in the referred standard. Before starting the tests, the performance of the generator shall be verified. At least 10 discharges shall be applied. For EUT not equipped with a ground terminal, the EUT shall be fully discharged between discharges. Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied.

Direct application: In the contact discharge mode to be carried out on conductive surfaces, the electrode shall be in contact with the EUT. In the air discharge mode on insulated surfaces, the electrode is approached to the EUT and the discharge occurs by spark.

Indirect application: The discharges are applied in the contact mode to coupling planes mounted in the vicinity of the EUT.

The test shall be done with the meter in operating conditions. The voltage circuits shall be energised with U_{nom} and the current and auxiliary circuits shall be open, without any current. No significant fault shall occur.

Test severity:

Contact discharge voltage[1]:   8 kV

Air discharge voltage[2]:   15 kV

(1) Contact discharges shall be applied on conductive surfaces.

(2) Air discharges shall be applied on non-conductive surfaces.

The EUT shall be tested as an table top equipment

Meters constructed with passive elements only, as for example electromechanical meters, may be regarded as immune to electrostatic discharges.

7.3.2.4 Fast transients

Applicable standards IEC 61000-4-1, IEC 61000-4-4.

Object of the test: To verify compliance to the requirements of 4.2.4.4, Table 6 under conditions where electrical bursts are superimposed on voltage and current circuits, and I/O and communication ports

Test procedure in brief: A burst generator shall be used with the performance characteristics as specified in the referred standard. The test consist of exposure to bursts of voltage spikes for which the repetition frequency of the impulses and peak values of the output voltage on 50 Ohm and 1000 Ohm load are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT. Both positive and negative polarity of the bursts shall be applied. The duration of the test shall not be less than 1 min for each amplitude and polarity. For the coupling of the bursts into the I/O and communication lines with a reference voltage over 40 V, a capacitive coupling clamp as defined in the standard shall be used. The test pulses shall be continuously applied during the measuring time.

Test conditions:
- The EUT shall be tested as a table top equipment
- The EUT voltage and auxiliary circuits shall be energised with reference voltage
- The cable length between coupling device and EUT shall be 1 m.
- The test voltage shall be applied in common mode (line-to-earth) to:

    a) the voltage circuits;

    b) the current circuits, if separated from the voltage circuits in normal operation;

    c) the auxiliary circuits, if separated from the voltage circuits in normal operation and with a reference voltage over 40 V.

Test severity:

- Test voltage on the current and voltage circuits: 4 kV.
- Test voltage on auxiliary circuits with a reference voltage over 40 V: 2 kV.
- Duration of each test: 60 s on each polarity.

The function of the meter shall not be perturbed, and the error shift, compared to the intrinsic error at reference conditions, shall be less than given in Table 14 ..

Mandatory test points: $10I_{tr}$, PF=1.

Table 14. Limits of significant fault for fast transients

Class	Limit for significant fault
A	6.0
B	4.0
C	2.0
D	1.0

7.3.2.5 Voltage dips and interruptions

Applicable standards IEC 61000-4-11, IEC 61000-6-1, IEC 61000-6-2.

Object of the test: To verify compliance to requirements of 4.2.4.4, Table 6 under conditions of short time mains voltage reductions (dips and interruptions).

Test procedure in brief: A test generator suitable to reduce for a defined period of time the amplitude of the AC mains voltage is used. The performance of the test generator shall be verified before connecting the EUT.

Meters constructed with passive elements only, as for example electromechanical meters, may be regarded as immune to voltage dips and interruptions.

The mains voltage reductions shall be repeated 10 times with an interval of at least 10 seconds.

The tests shall be carried out under the following conditions:
- voltage circuits energized with U_{nom};
- without any current in the current circuits.

Test severity

Voltage reduction tests:

Test	test a	test b	test c
Reduction:	30 %	60 %	60 %
Duration:	0.5 cycles	5 cycles	50 cycles

Voltage interruption test:

I

Interruption:	> 95 %
Duration:	250 cycles

No significant fault shall occur.

7.3.2.6 Surges on AC mains power lines

Applicable standard: IEC 61000-4-5.

Object of the test: To verify compliance with the provisions in 4.2.4.4 under conditions where electrical surges are superimposed on the mains voltage and - if applicable - on I/O and communication ports.

Test procedure in brief: A surge generator shall be used with the performance characteristics as specified in the referred standard. The test consists of exposure to surges for which the rise time, pulse width, peak values of the output voltage/current on high/low impedance load and minimum time interval between two successive pulses are defined in the referred standard. The characteristics of the generator shall be verified before connecting the EUT.

The following limitations and conditions shall apply:

- The test is not applicable for meters intended to be operated with voltage transformers
- meter in operating condition:
  - voltage circuits energized with nominal 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);
- phase angle: pulses to be applied at 60° and 240° relative to zero crossing of AC supply;

Test severity:

Auxiliary circuits with a reference voltage over 40 V:

Line to line: Test voltage 1.0 kV, generator source impedance 42 Ω

Line to earth[1]: Test voltage 2.0 kV, generator source impedance 42 Ω

Number of tests: 5 positive and 5 negative;

Repetition rate: maximum 1/min.

Voltage circuits:

Line to line: Test voltage: 2.0 kV, generator source impedance: 2 Ω

Line to earth[1]: Test voltage: 4.0 kV, generator source impedance: 2 Ω

Number of tests: 5 positive and 5 negative;

Repetition rate: maximum 1/min.

(1): For the case the meter has an earth separated from the neutral.

7.3.2.7 Damped oscillatory waves immunity test

The test shall be carried out in accordance with IEC 61000-4-12.

Object of the test: To verify compliance to the provisions of 4.2.4.4, Table 6 under conditions of damped oscillatory waves.

Test procedure in brief: The meter is subjected to damped oscillatory voltage waveforms with a peak voltage according to the test severity stated below.

The following limitations and conditions shall apply:

- the test is only for meters intended to be operated with voltage transformers;
- meters shall be tested as table top equipment;
- meters shall be in operating condition:
  - voltage circuits energized with nominal voltage;
  - with $I = 20\ I_{tr}$ and power factor one and 0.5 inductive;

Test severity:

- test voltage on voltage circuits and auxiliary circuits with a operating 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)

During the test the meter shall not be perturbed and the error shift shall be less than the limits given in Table 15.

Mandatory test points: $10I_{tr}$, PF=1

Table 15. Limits of significant fault for damped oscillatory wave

Class	Limit for significant fault
A	3.0
B	2.0
C	1.0
D	??

7.3.2.8 Short-time overcurrent

Object of the test: To verify compliance to requirements of 4.2.4.4, Table 6 under conditions of short time overcurrent.

General outline: It shall be tested that the meter is be able to handle the current caused by a short-circuit within the load it is metering, when that load is protected with the proper fuses or breakers.

Test current: For direct connected meters: $30*I_{max}$ +0 % -10%, for one half cycle at rated frequency or equivalent. For meters connected through current transformers: A current equivalent to $20*I_{max}$ +0 % -10%, for 0,5s.

The test current shall be applied in one phase at the time. The test current value given is the rms value, not the peak value.

No damage shall occur. With the voltage still connected the meter shall be allowed to return to normal temperatures (about one hour). The error shift, compared to the initial error before the test, shall then be less the limit of error shift given by the Table 16.

Mandatory test points: $10I_{tr}$, PF=1.

Table 16 Limit of error shift for short-time overcurrent

Class	Limit of error shift(%) for transformer operated meters	Limit of error shift(%) for direct connected meters
A	1.0	1.5
B	0.5	1.5
C	0.3	0.5
D	0.1	0.2

7.3.2.9 Impulse voltage

7.3.2.9.1 General

Object of the test: To verify compliance to requirements of 4.2.4.4, Table 6 under conditions of impulse voltage.

The meter and its incorporated auxiliary devices, if any, shall be such that they retain adequate dielectric qualities, taking account of the atmospheric influences and different voltages to which they are subjected under normal conditions of use.

The meter shall withstand the impulse voltage test as specified below. The test shall be carried out only on a complete meter.

For the purpose of this test, the term "earth" has 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 part of it is made of insulating material, the "earth" is a conductive foil wrapped around the meter touching all accessible conductive parts and connected to the flat, conducting surface on which the meter is placed. 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 voltage tests, the circuits that are not under test shall be connected to the earth.

The conditions for high voltage tests are:

·   ambient temperature: 15 °C to 25 °C;

·   relative humidity: 25 % to 75 %;

·   atmospheric pressure: 86 kPa to 106 kPa.

After the impulse tests, there shall be no damage to the meter and no significant fault shall occur.

7.3.2.9.2 Impulse Voltage Test

The test shall be performed as defined in 61000-4-5

Conditions:

- ·   impulse waveform: 1.2/50 µs impulse specified in IEC 60060;
- ·   voltage rise time: ± 30 %;
- ·   voltage fall time: ± 20 %;
- ·   source series impedance: 500 Ω± 50 Ω;
- ·   source energy: 10.0 J ± 1.0 J;
- ·   test voltage: in accordance with Table 17;
- ·   test voltage: +0 –10 %.

For each test the impulse voltage is applied ten times with one polarity and then repeated ten times with the other polarity. The minimum time between impulses shall be 3 s.

Table 17. Impulse voltage test levels

Voltage phase to earth derived from rated system voltage	Rated impulse voltage V	
V	Low system exposure	high system exposure
$V \leq 100$	2 500	3 000
$100 \leq V \leq 150$	4 000	6 000
$150 \leq V \leq 300$	6 000	10 000
$300 < V \leq 600$	8 000	12 000

Note: A highly exposed system is one which may be subjected to high voltage impulses and which provides little or no attenuation of such impulses such as power distribution systems using overhead cables and/or meters mounted on the exterior of premises.

Note – National authority may change the applicable rated impulse voltage levels.

7.3.2.9.3 Impulse voltage tests for circuits and between circuits

The test shall be made independently on each circuit (or assembly of circuits) which is insulated from 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 current circuits of a measuring element are connected together in normal use, the test shall be made on the whole. 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. The other end of this current circuit shall be open.

When the voltage and current circuits of the same measuring element are separated and appropriately insulated in normal use (e.g. each circuit connected to 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 by being tied together with a voltage circuit during tests. The other auxiliary circuits shall not be tested.

7.3.2.9.4 Impulse 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.

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. During this test no flashover, disruptive discharge or puncture shall occur.

7.3.2.10 Earth fault

Object of the test: To verify compliance to the provisions of 4.2.4.4, Table 6 under conditions of earth fault.

Only for three-phase four-wire transformer-operated meters, connected to distribution networks which are equipped with earth fault neutralizers or in which the star point is isolated (in the case of an earth fault and with 10 % overvoltage, the line-to-earth voltages of the two lines which are not affected by the earth fault will rise to 1,9 times the nominal voltage), the following requirements apply:

For a test under a simulated earth fault condition in one of the three lines, all voltages are increased to 1,1 times the nominal voltages during 4 h. The neutral terminal of the meter under test is disconnected from the ground terminal of the meter test equipment (MTE) and is connected to the MTE's line terminal at which the earth fault has to be simulated (see Figure 3). 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. After the test, the meter shall show no damage and shall operate correctly.

The change of error measured when the meter is back at nominal working temperature shall not exceed the limits given below I Table 18.

Mandatory testpoints: I = 10 I_{tr}, power factor = 1.

Table 18 Limit for significant fault for earth fault test

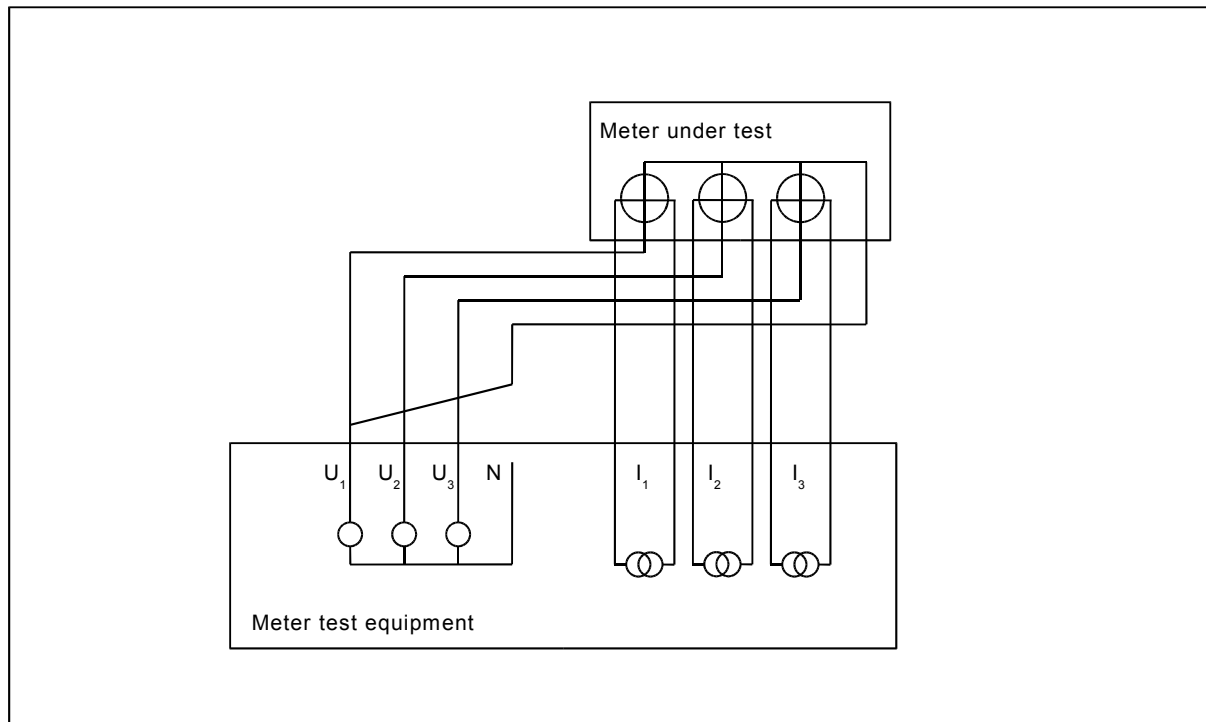| Class	Limit of eror change [%]
A	1.0
B	0.7
C	0.3
D	0.1

Figure 3. Set-up for earth fault test.

7.3.2.11 Operation of auxiliary devices

It shall be tested that the operation of auxiliary devices does not disturb the meter. The meter shall be operated at reference conditions and the error is continuously monitored, while auxiliary devices such as communication devices, relays and other I/O circuits are operated. The functionality of the meter shall not be impaired and the error shift due to the operation of shall always be below 1/10 of mpe.

Mandatory testpoints: I_{tr} and I_{max}.

7.3.2.12 Mechanical tests

7.3.2.12.1 Vibrations

Applicable standard IEC 60068-2-47, IEC 60068-2-64.

Test procedure in brief: The test consists of exposure to the vibration level for a time sufficient for testing the various functions of the EUT during the exposure. The EUT shall, in turn, be tested in three, mutually perpendicular axes mounted on a rigid fixture by its normal mounting means.

The EUT shall normally be mounted so that the gravitational force acts in the same direction as it would in normal use. Where the effect of gravitational force is not important the EUT may be mounted in any position.

Test severity

Total frequency range	10 – 150 Hz
Total RMS level	7 m·s^{-2}
ASD level 10-20 Hz	1 m^2·s^{-3}
ASD level 20-150 Hz	-3 dB/octave
Duration per axis:	at least 2 minutes.

After the test it shall be tested that the functionality of the meter has not been impaired and that the error at 10 I_{tr} has not changed more than 1/10 of base maximum permissible error.

7.3.2.12.2 Shock

Applicable standard IEC 60068-2-31. (Ed. See also alternative text below provided by Aaron Snyder)

Test method: Dropping on to a face.

Test procedure in brief: The EUT, placed in its normal position of use on a rigid surface, is tilted towards one bottom edge and is then allowed to fall freely on to the test surface. The height of fall is the distance between the opposite edge and the test surface. However, the angle made by the bottom and the test surface shall not exceed 30°.

Test severity:

Height of fall:	25 mm
Number of falls (on each bottom edge):	1

After the test it shall be tested that the functionality of the meter has not been impaired and that the error at 10 I_{tr} has not changed more than 1/10 of base maximum permissible error.

(ED: Alternative test provided by Aaron Snyder:)

Applicable standard IEC 60068-2-32 (Editors Note: D11 points to IEC 60068-2-31 (only a part of the meter lifted); -32 is free fall).

Test severity:

Test surface:	concrete or steel
Height of fall:	50 mm
Number of falls on each face:	2
Attitudes (landing faces of the meter):	at least five including the bottom, top, one side, front, back

Test procedure:

The EUT, placed on the test surface, is tilted towards one edge of the tested face, lifted to the proper height and is then allowed to fall freely on to the test surface.

The height of fall is the shortest distance between the test object and the test surface. The angle between the face of the meter and the test surface shall be 15-30°.

After the test it shall be tested that the functionality of the meter has not been impaired and that the error at 10 I_{tr} has not changed more than 1/10 of base maximum permissible error.

7.3.2.13 Protection against solar radiation

The object of the test is to verify compliance with the provisions regarding solar radiation of sections 4.4, 4.5.1, and 4.6.1.

The test shall be carried out according to IEC 60068-2-5, under the following conditions:

- for outdoor meters only;

- meter in non-operating condition;

- test procedure A (8 h irradiation and 16 h darkness);

- upper temperature: +55 °C;

- duration of the test: 3 cycles or 3 days.

After the test the meter shall be visually inspected and a function test shall be made. The appearance and, in particular, the legibility of markings and displays shall not be altered. The means to protect the metrological properties, such as the case and sealing shall not be affected. The function of the meter shall not be impaired.

7.3.2.14 Climatic tests

7.3.2.14.1 Extreme temperatures - dry heat

Applicable standards: IEC 60068-2-2, IEC 60068-3-1.

Object of the test: To verify compliance to the provisions of 4.2.4.4, Table 6 under conditions of dry heat.

The test consists of exposure to the specified high temperature under "free air" conditions for 2 hours, with the EUT at non-operating state (the time is the time after the EUT has reached temperature stability).

The change of temperature shall not exceed 1 °C/min during heating up and cooling down.

The absolute humidity of the test atmosphere shall not exceed 20 g/m$_3$.

Test severity: The test shall be performed at a standard temperature one step higher than the standard temperature for which the meter is specified.

Possible temperatures: 40   55   70   85   °C

After the test it shall be tested that the functionality of the meter has not been impaired and that the error at 10 I_{tr} has not changed more than 1/10 of base maximum permissible error.

7.3.2.14.2 Extreme temperatures - cold

Applicable standards IEC 60068-2-1, IEC 60068-3-1.

Object of the test: To verify compliance to the provisions of 4.2.4.4, Table 6 under conditions of low temperatures.

The test consists of exposure to the specified low temperature under "free air" conditions for 2 hours with the EUT at non-operating state (the time is the time after the EUT has reached temperature stability).

The change of temperature shall not exceed 1 °C/min during heating up and cooling down.

Test severity: The test shall be performed at a standard temperature one step normally lower than the standard temperature for which the meter is specified.

Possible temperatures: -10   -25   -40   -55 °C

After the test it shall be tested that the functionality of the meter has not been impaired and that the error at 10 I_{tr} has not changed more than 1/10 of base maximum permissible error.

7.3.2.14.3 Damp heat for humidity class H1

Applicable standards IEC 60068-2-78, IEC 60068-3-4.

To verify compliance with the provisions in Table 4 and 4.2.4.4, Table 6 under conditions of high humidity and constant temperature. For meters that are specified for enclosed locations where the meters are not subjected to condensed water, precipitation, or ice formations (H1). The test consists of exposure to the specified high level temperature and the specified constant relative humidity for a certain fixed time defined by the severity level. The EUT shall be handled such that no condensation of water occurs on it.

The test shall be carried out under the following conditions:

-Voltage and auxiliary circuits energized with reference voltage;

-Without any current in the current circuits.

Test severity:

Temperature   30 °C

Humidity   85 %

Duration   2 days

During the test no significant fault shall occur, i.e. there shall be no change of registers higher than the critical change value.

Immediately after the test the meter shall operate correctly and comply with the accuracy requirement ofTable 4.

24 h after the test the meter should be submitted to a functional test, showing that the meter should operate correctly. No mechanical damage or corrosion of that can affect the functional properties shall occur.

7.3.2.14.4 Damp heat, cyclic (condensing) for humidity class H2 and H3

Applicable standards IEC 60068-2-30, IEC 60068-3-4.

To verify compliance with the provisions in Table 4 and Table 6 under conditions of high humidity and temperature variations. For meters that are specified for enclosed locations where meters can be subjected to condensed water and meters specified for open locations(humidity class H2 and H3).

Test procedure in brief: The test consists of exposure to cyclic temperature variation between 25 °C and the appropriate upper temperature, maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at 93 % at the upper temperature phases. Condensation should occur on the EUT during the temperature rise.

The 24 h cycle consists of:
1) temperature rise during 3 h
2) temperature maintained at upper value until 12 h from the start of the cycle
3) temperature lowered to lower value within 3 h to 6 h, the rate of fall during the first hour and a half being such that the lower value would be reached in 3 h

4) temperature maintained at lower value until the 24 h cycle is completed.

The stabilizing period before and recovery after the cyclic exposure shall be such that all parts of the EUT are within 3 °C of their final temperature.

The test shall be carried out under the following conditions:
- Voltage and auxiliary circuits energized with reference voltage;
- Without any current in the current circuits.
- Mounting position according to manufacturers specification

Meters that are specified for enclosed locations where meters can be subjected to condensed water shall be tested at severity level 1. Meters specified for open locations shall be tested at severity level 2.

Severity levels	1	2	unit
Upper temperature:	40	55	°C
Duration	2	2	cycles

During the test no significant fault shall occur, i.e. there shall be no change of registers higher than the critical change value.
Immediately after the test the meter shall operate correctly and comply with the accuracy requirement of Table 4.

24 h after the test the meter should be submitted to a functional test, showing that the meter should operate correctly. No mechanical damage or corrosion of that can affect the functional properties shall occur.

7.3.2.14.5 Water test

Applicable standards: IEC 60068-2-18, IEC 60512-14-7, IEC 60529

To verify compliance with the provisions in 4.2.4.4, Table 6 under conditions of rain and water splashes. The test is applicable to meters that are specified for open locations (H3).

Test procedure in brief: The EUT is mounted on an appropriate fixture and is subjected to impacting water generated from either an oscillating tube or a spray nozzle used to simulate spraying or splashing water.

The instrument shall be in functional mode during the test under the following conditions:

Flow rate (per nozzle): 0.07 L/min

Duration: 10 min

Angle of inclination: 0 ° and 180 °

During the test no significant fault shall occur, i.e. there shall be no change of registers higher than the critical change value.

Immediately after the test the meter shall operate correctly and comply with the accuracy requirement of Table 2. Base maximum permissible error.

24 h after the test the meter should be submitted to a functional test, showing that the meter should operate correctly. No mechanical damage or corrosion of that can affect the functional properties shall occur.

8 Examination for conformity with type

It shall be ensured that the documentation supplied by the manufacturer complies with the requirements given in 5.1 Documentation.

I shall be ensured that the test scope and the used test levels are in line with the specification given by the manufacturer and the requirements of 4 Metrological Requirements.

It shall be ensured that the type test results comply with the requirements given in 4 Metrological Requirements. It shall be ensured that the uncertainty of measurements is sufficiently low to discriminate between a pass and a fail condition. Especially, error measurement for 7.2 Tests for maximum permissible error, shall be performed with an uncertainty less than one fifth of the maximum permissible error given for corresponding test point, if nothing else is stated in the test section. Then, if the measured error or error shift is less than the corresponding maximum permissible error or maximum permissible error shift or limit of error shift, respectively, the meter shall be deemed to have passed.

It shall be ensured that the meter complies with the general requirement and other requirements without corresponding test given in 4 Metrological Requirements.

9 INITIAL VERIFICATION AND SUBSEQUENT-VERIFICATION

9.1 General

Initial verification or re-verification shall be carried out either individually or statistically. In all cases the meters shall conform to the requirements of this Recommendation. The following minimum programme applies for initial verification, individual and statistical. If the meter has been repaired or otherwise changed it also applies for re-verification. For individual and statistical re-verification on meters that have not been repaired or otherwise changed, the programme may be modified and further reduced.

9.2 Testing

9.2.1 Calibration status

Check that the test system used has sufficient accuracy to verify the meters under test, and that the calibration is valid.

9.2.2 Conformity check

Check that the instrument is manufactured in conformity with the type approval documentation.

9.2.3 Warming-up

It may be necessary to connect the meter some time before running for warming up. The length of the warming-up period depends on the actual type of instrument and shall be determined in advance.

9.2.4 Test for base maximum permissible error

The minimum programme consists of:

9.2.4.1 No-load check

For this test, the current in the current circuit shall be 0.2 I_{st} at unity power factor. The test shall be performed at U_{nom}. For meters with test output, the output of the meter shall not produce more than one pulse. For an electromechanical meter, the rotor of the meter shall not make a complete revolution. The minimum test period ∆t shall be

$$\Delta t \geq \frac{75 \cdot 10^3}{k \cdot m \cdot U_{nom} \cdot 0.2 \cdot I_{st}} \text{ minutes}$$

- k is the number of pulses emitted by the output device of the meter per kilowatthour (imp/kWh) or number of revolutions;
- m is the number of measuring elements;

A meter with more than one connection mode shall be tested in all modes. However, if the test is made on the site of use, only the actual mode need be tested.

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

For a meter which function is well known and is such that it can be determined in shorter time that it will not register energy at the test current, such an alternative method and test time shall be allowed.

9.2.4.2 Starting current check

Test is performed at I_{st} and power factor one. If the initial verification is an on-going process on a large number of identical units, it will be sufficient if the error curve from 0 up to I_{min} is recorded on a sample batch every 3 months for the particular meter type. For the regular initial verification it suffices if the meter is running visibly at the starting current. A meter with more than one connection mode shall be tested in all modes. However, if the test is made on the site of use, only the actual mode need be tested.

9.2.4.3 Current dependence

: As minimum, the accuracy requirements shall be checked for the following currents:

- I_{min},   PF=1;
- I_{tr},   PF=1;
- I_{tr},   PF=0,5 ind.
- 10 I_{tr},   PF=1;
- 10 I_{tr},   PF=0,5 ind.
- I_{max},   PF=1;
- I_{max},   PF=0,5 ind.

9.2.4.4 Current dependence tests for three-phase meters

The test is applicable to meters that have an alternative single-phase connection mode: the single-phase load test may be restricted to:

for each phase separately at 10 I_{tr} at PF=1 and 10 I_{tr} at PF = 0.5 inductive.

9.2.4.5 Check of the register

The register is checked by putting energy through the meter. If test (pulse) outputs are used for tests of accuracy requirements, a test must be made to ensure that the relation between the basic energy register and the used test output(s) complies with the manufacturers specification. The test may be made by putting an energy E through the meter, where E is at least:

$$E_{min} = \frac{R \cdot 10 \cdot 100\%}{\text{base maximum permissible error(\%)}}$$

where R is the basic energy register resolution.

The relative difference between the registered energy and the energy put through the meter as given by the number of pulses from the test output shall be computed. The relative difference must not be greater than equivalent to one tenth of the base maximum permissible error. The test may be performed at one arbitrary current $I \geq I_{tr}$.

9.2.5 Sealing

If the seals are removed during the initial test, or if it is not yet applied, the meters shall be sealed in accordance with the type approval documentation.

9.3 Reference conditions for initial and subsequent verifications in laboratory

Table 19 Reference conditions and their tolerances for initial and subsequent verification

Quantity	Reference conditions	Tolerance
Voltage(s)	Unom	±2 %
Ambient temperature	23ºC	±5ºC
Frequency	fnom	±0.5 %
Wave-form	Sinusoidal	d ≤ 2 %
Magnetic induction of external origin at reference frequency	0 T	B ≤ 0.1 mT
Electromagnetic RF fields 150 kHz- 2GHz	0 V/m	< 2 V/m
Operating position for instruments sensitive to position	Mounting as stated by manufacturer	± 3.0 º
Phase sequence for polyphase meters	L1, L2, L3	-
Load balance	Equal current in all current circuits	±5 % and ±5 º

Table 20 Load conditions and their tolerances in tests for initial and subsequent verification

Current(s)	Current range of device under test	Class A,B: ± 10 % Class C,D: ±10 %
Power factor	Power factor range of device under test	current to voltage phase difference ±5 º

9.4 Additional requirements for the statistical verifications and in-service inspections

Under consideration pending work in OIML TC3 subcommittee 4.

**Part 3 Test report Format
(to be drafted later)**

Part 3 Test report Format

Annex A

Informative

Annex B Estimate of conventional overall maximum probable uncertainty

Annex CEstimation based on the requirements of this Recommendation

This recommendation permits a base maximum permissible error plus an error shift caused by influence quantities. The actual error of a complying meter when in use could therefore exceed the base maximum permissible error. There is a need to estimate a conventional overall maximum permissible error that indicates the largest error that can reasonably be attributed to a meter type that complies with this recommendation. This entails estimating the uncertainty of measurement of an arbitrary meter at arbitrary conditions (within the rated operating conditions).

However, adding the base maximum permissible error and all error shifts algebraically would give a much too pessimistic estimate of the metering uncertainty, for two reasons. For an arbitrary set of influence factor values, some of the error shifts will be low and some will probably have opposite signs, tending to equal out each other. Further, the electricity meter is an integrating device and the error caused by influence quantities will to some extent average out when the values of the influence factors vary over time.

Ignoring the integrating effect but assuming that none of the effects of the influence factors are correlated may be a fair presumption. Further, it is a safe assumption that the values of the influence quantities are more likely to be close to the reference values than close to limits of the rated operated conditions. Assuming that the influence quantities, and the effects of the influence factors, will occur as Gaussian distributions and cause a standard uncertainty that is half the maximum permissible error shift is therefore acceptable, being a more liberal estimate than assuming a rectangular distribution and a more conservative estimate than assuming a triangular distribution.

With the above assumptions, the conventional maximum permissible error (with a coverage factor of two corresponding to a coverage probability of approximately 95 %) can be estimated using the formula[1]:

$$u = 2 * \sqrt{\frac{u_{base}^2}{4} + \frac{u_{voltage}^2}{4} + \frac{u_{frequency}^2}{4} + \frac{u_{unbalance}^2}{4} + \frac{u_{harmonic}^2}{4} + \frac{u_{tilt}^2}{4} + \frac{u_{temperature}^2}{4}}$$

where:

u_{base} is the base maximum permissible error;

$u_{voltage}$ is the maximum error shift permitted for voltage variation;

$u_{frequncy}$ is the maximum error shift permitted for frequency variation;

$u_{unbalance}$ is the maximum error shift permitted for unbalance variation;

$u_{harmonics}$ is the maximum error shift permitted for the variation of harmonic content;

u_{tilt} is the maximum error shift permitted for tilt;

$u_{temperature}$ is the maximum error shift permitted for temperature variation.

Note (1). This is line with the ISO Guide to the expression of uncertainty of measurement, (GUM)

Annex DEstimation based on type test results and specific conditions

The conventional overall maximum permissible error can also be estimated for a certain type of meter based on type test results. Type test results can often show a smaller variation than that required by this Recommendation, leading to an assured smaller value for the conventional overall maximum permissible error. In such an evaluation it is advised to use rectangular distributions for the effects of influence factors, since it cannot be safely assumed that the distribution is Gaussian

The conventional overall maximum permissible error based on test results can then be estimated using the formula:

$$u = 2 * \sqrt{\frac{u_{base}^2}{3} + \frac{u_{voltage}^2}{3} + \frac{u_{frequency}^2}{3} + \frac{u_{unbalance}^2}{3} + \frac{u_{harmonic}^2}{3} + \frac{u_{tilt}^2}{3} + \frac{u_{temperature}^2}{3}}$$

where:

u_{base} is the maximum error found in the test for base maximum error, algebraically added to the measurement uncertainty of the type test[2];

$u_{voltage}$ is the maximum error shift found in the test for voltage variation, algebraically added to the measurement uncertainty of the type test;

$u_{frequncy}$ is the maximum error shift found in the test for frequency variation, algebraically added to the measurement uncertainty of the type test;

$u_{unbalance}$ is the maximum error shift found in the test for unbalance variation, algebraically added to the measurement uncertainty of the type test;

$u_{harmonics}$ is the maximum error shift found in the test for variation of harmonic content, algebraically added to the measurement uncertainty of the type test;

u_{tilt} is the maximum error shift found in the test for influence of tilt, algebraically added to the measurement uncertainty of the type test;

$u_{temperature}$ is the maximum error shift found in the test for temperature variation, algebraically added to the measurement uncertainty of the type test.

Note (2). The uncertainty component must include the measurement uncertainty. Since one term is a known value and the other an uncertainty they cannot be treated as two uncorrelated statistical distributions, and they must hence be algebraically added.

The above calculations do not take into account the integration effect in conjunction with load profiles, ambient temperature variation etc. Such consideration may also be used to estimate the conventional overall maximum permissible error under specific conditions.

Annex E

Informative

Annex FLegislation considerations

There are a number of conditions that will vary from country to country or region to region and there may also be different applications of meters within countries. Making a Recommendation for one single type of meter that could cope with all conditions and application would not be viable. Neither would making a number of Recommendations, the number of possible combination are too great. The suitable combination of condition and application differences and requirements must be made by the legislators.

Options are given in the Recommendation for a number of conditions. These are

a) Nominal voltage

b) Nominal frequency

c) Rated temperature

d) Level of protection from water and humidity

e) Level of protection from impulse voltages

f) Handling of energy flow direction

In some countries or regions there may also be demands of certain

g) Electrical interface

h) Mechanical interface and housing

Further, while the maximum current is most often given by the installation, the value of the transitional current, or the ratio between the maximum current and the transitional current, is important for the end customers with low power consumption. Customers could experience large relative metering errors if the load current is lower than the transitional current for a large part of the time.

The values of I_{tr} and I_{max} should preferably be chosen from the below table.

Table 21. Preferred current ranges

Type of meter connection	Preferred values of I_{tr} and I_{max} (Amperes)	Other values of I_{tr} and I_{max} (Amperes)
Direct connection	Standard I_{tr} values: 0.125, 0.25, 0.5, 1, 2, 3. Standard I_{max} values: 10, 20, 40, 60, 80, 100, 120, 200, 320	Other I_{tr} values: 0.75, 1.5, 2, 2.5, 4 5 Other I_{max} values:30, 50, 160
Connection through current transformer (s)	Standard I_{tr} values: 0.05, 0.1, 0.25 Standard I_{max} values: 1.2, 1.5, 2, 2.4, 3, 4, 6, 7.5, 10, 20	Other I_{tr} values: 0.125 Other I_{max} values 3.0, 3.75, 5

Note 1 - The current range of transformer operated meters should be compatible with the current range of current transformers.

Note 2 – The legislator may prescribe the maximum permissible I_{tr} value, prescribe a minimum current range, or a minimum ratio between I_{max} and I_{tr}. These can be prescribed as absolute values or values based on the typical power demand for certain types of customers etc.

Annex GChoice of class index

More accurate meters should be used when metering larger flows of electricity in order to reduce the economic impact of the unavoidable errors in the metering. While class A can be acceptable for low consumptions, e.g. households with only lighting and electronics as the load, higher class indices should be used for larger consumptions.

The accuracy of the meter will be independent of the power grid characteristics for most types of meter connection modes. However, for some connections modes where there are underlying assumptions of grid symmetry and/or lack of leakage currents there may be a need for evaluation of the influence of grid characteristics, especially for meters with the higher class indices. It is quite possible that the error contributions due to grid characteristics are larger than the contributions from the meter itself, especially for the higher class indices. Therefore, there might be reason to limit the use of such connection modes.

Annex HThings not handled in this document

This is a document describing the relevant metrological requirements of an electricity meter. Therefore there are areas that are or should or may be regulated by legislation that are not covered. Some of these things may be:

a) EMC – emission

b) Electrical safety and personal safety

c) Security of communication protocols and further handling of measurement results