1 CD OIML R 46-2

Date: **20 December 2022**

Reference number: **TC12_p1_N056**

Supersedes document: OIML/TC12/p1/N045

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TITLE OF THE CD (English):

OIML R 46-2

Electrical Energy Meters – Alternating Current (a.c.)

Part 2: Metrological controls and performance tests

Contents

Foreword

[To be inserted by BIML]

1 Type evaluation and approval

1.1 General

A type of meter is presumed to comply with the requirements of OIML R 46-1 if it has passed the examination and tests specified in this Part 2. A type of meter may only be deemed to have passed examination for type approval if the results of all type tests comply with the requirements given in sections 5, 6 and 7 of OIML R 46-1. The scope of the tests performed and test severities used shall be consistent with the manufacturer's specifications.

The measurement uncertainty shall be small enough to allow clear discrimination between a pass result and a fail result. In particular, an uncertainty less than one third the maximum permissible error given for the corresponding test point must be obtained for tests described in section 2.2, unless otherwise specified in the relevant test description.

1.2 Documentation

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

- identification of the type, including
  - name or trademark and type designation,
  - version(s) of hardware and software,
  - drawing of name plate;
- metrological characteristics of the meter, including
  - a description of the principle(s) of measurement,
  - metrological specifications such as accuracy class and rated operating conditions (OIML R 46-1, section 6.1 and 6.2),
  - any steps which should be performed prior to testing the meter;
- the technical specification for the meter, including
  - a block diagram with a functional description of the components and devices,
  - drawings, diagrams and general software information, explaining the construction and operation, including interlocks,
  - description and position of seals or other means of protection,
  - documentation related to durability characteristics,
  - any document or other evidence that the design and construction of the meter complies with the requirements of this Recommendation,
  - specified clock output frequencies of oscillators and multiplier circuits,
- user manual;
- installation manual;
- a description of the checking facility preventing significant faults to occur, if applicable;

In addition, software documentation shall include

- a description of the legally relevant software and how the requirements are met:
  - list of software modules that belong to the legally relevant part including a declaration that all legally relevant functions are included in the description;
  - description of the software interfaces of the legally relevant software part and of the commands and data flows via this interface including a statement of completeness;
  - description of the generation of the software identification;

- list of parameters to be protected and description of protection means;

- a description of security means of the operating system (password, etc. if applicable);
- a description of the (software) sealing method(s);
- an overview of the system hardware, e.g. topology block diagram, type of computer(s), type of network, etc.
- where a hardware component is deemed legally relevant or where it performs legally relevant functions, this should also be identified;
- a description of the accuracy of the algorithms (e.g. filtering of A/D conversion results, price calculation, rounding algorithms, etc.);
- a description of the user interface, menus and dialogues;
- the software identification and instructions for obtaining it from an instrument in use;
- list of commands of each hardware interface of the measuring instrument / electronic device / sub-assembly including a statement of completeness;
- list of durability errors that are detected by the software and if necessary for understanding, a description of the detecting algorithms;
- a description of data sets stored or transmitted;
- if fault detection is realized in the software, a list of faults that are detected and a description of the detecting algorithm;
- the operating manual.

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 assertion that the design and characteristics of the measuring instrument comply with the requirements of this Recommendation.

1.3 Type definition

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

1.4 Sample meters and modifications

The manufacturer shall provide at least as many specimens of the meter as are required by the national authority. 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 decide on the appropriate means of evaluation for the modified pattern. For instance, the issuing body may deem it sufficient to perform limited tests on the characteristics that may be affected by the modifications.

1.5 Reference meter

The reference meter shall be at reference conditions.

The reference meter shall measure the total active energy (fundamental + harmonics) in the presence of harmonics.

In the test report:

For accredited test laboratories: proof of accreditation;

For other laboratories: identification of the reference meter, and other test equipment used: brand name, product type, model and serial number; calibration dates of test equipment.

Reference meter shall have an uncertainty less than one fifth the maximum permissible error for the corresponding test point for a given tests described in section 2.2, unless otherwise specified in the relevant test description.

2 Test procedures for type approval

2.1 General

2.1.1 Test program

The initial intrinsic error shall be determined as the first test on the meter, as described in 2.2.1.

At the beginning of any series of tests, the meter shall be allowed to stabilize with voltage circuits energized for a period of time specified by the manufacturer.

The determination of the intrinsic error (at reference conditions) shall be carried out before conducting the influence and disturbance tests.

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 manufacturer's specification.

If a meter is specified with alternate connection modes, such as one-phase connections for poly-phase meters, the tests for compliance with maximum permissible errors (2.2.1 to 2.2.5) shall be made for all specified connection modes.

Note: National authorities may prescribe more stringent test regimes than those described in this section.

2.1.2 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 1 during type approval tests. Load conditions shall be in accordance with

Table 2.

Table 1 - Reference conditions and their tolerances

Quantity	Reference conditions	Tolerance
Voltage(s) [2]	U_{nom}	± 1 %
Ambient temperature	23 ºC[1]	± 2 ºC
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 30 kHz – 6 GHz	0 V/m	≤ 1 V/m
Operating position for instruments sensitive to position	Mounting as stated by manufacturer	± 0.5º
Phase sequence for poly-phase meters	L1, L2, L3	-
Load balance	Equal current in all current circuits	± 2 % (current) and ± 2º (phase angle)

(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 an appropriate uncertainty analysis is carried out.

(2) The requirement applies to both phase-to-phase and phase-neutral for poly-phase 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 2 - 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, E: ± 1 %
Power factor	Power factor range of device under test	Current to voltage phase difference ± 2º

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

Table 2.

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

2.1.3 Acceptance Criteria

The acceptance criteria in

Table 3 shall apply to the influence and disturbance tests specified in 2.3 and 2.4, unless therein specified otherwise.

Primary functions of electricity meters include:

a) energy registration

b) indicating display

c) operation of the supply control and load control switches

These primary functions shall be observed during testing specified in 2.3 and 2.4.

Table 3 – Acceptance criteria for influences and disturbances

Acceptance criteria	Description
Criteria A	During the test, a temporary degradation of primary functions is acceptable only within defined limits: **a) energy registration:** the variation in percentage error (fault for disturbances) shall be within the relevant limit of error shift (fault limit for disturbances) for the meter class specified in OIML R 46-1, 6.3.2, Tables 4 and 5 for influences and 6.4.2, Table 6 for disturbances. **b) indicating display:** degradation of display quality (colour, brightness, contrast, sharpness, geometry, etc.) during the test is acceptable; the indication of the content of energy registers shall remain unambiguously readable during the test. **c) supply and load control switches:** unexpected operation of the switch during the test shall not occur. During the test a temporary degradation or loss of other meter functions within the scope of this document is acceptable, except for a reset of embedded software (firmware). After the test, when the influence quantity or disturbance is removed, and the reference test conditions are restored, the meter shall show no damage and shall operate with no degradation of its metrological performance. All meters functions within the scope of this document shall be restored without any intervention of the operator and without the removal of the mains supply or the auxiliary power supply.

Criteria B	During the test, a temporary degradation of primary functions is acceptable provided that: **a) energy registration:** at any time during the test, and immediately after, the value of the energy registers shall not change by more than the critical change value. **b) indicating display:** degradation of display quality (colour, brightness, contrast, sharpness, geometry, etc.) during the test is acceptable; the indication of the content of energy registers may become unreadable during the test. **c) supply and load control switches:** unexpected operation of the switch during the test shall not occur. During the test a temporary degradation or loss of other meter functions within the scope of this document is acceptable, including a self-recovering reset of embedded software (firmware). After the test, when the disturbance is removed, and the reference test conditions are restored, the meter shall show no damage and shall operate with no degradation of its metrological performance. It shall be checked by measurement that the meter still fulfils the base maximum permissible error requirements. The mandatory test points for checking the base maximum permissible error are: 1) I_{tr}, PF = 1, 2) I_{tr}, PF = 0.5 inductive. All meters functions within the scope of this document shall be restored without any intervention of the operator and without the removal of the mains supply or the auxiliary power supply.

The critical change value (x) is derived from the following formula:

$$x = 10^{-6} \times m \times U_{nom} \times I_{max}$$

where

x is the critical change value expressed in kWh or kvarh

m is the number of measuring elements

U_{nom} is the nominal voltage expressed in volts

I_{max} is the maximum current expressed in amperes.

2.2 Tests for compliance with maximum permissible errors

2.2.1 Determination of initial intrinsic error

Object of the test:	To verify that the error of the meter at reference conditions is less than the relevant base mpe given in OIML R 46-1, 6.2.2 (Table 3).
Test procedure:	Meters that are specified as being capable of bidirectional or unidirectional energy measurement as described in OIML R 46-1, 7.6 shall meet the relevant base mpe requirements of OIML R 46-1, 6.2.2 (Table 3) for energy flow in both positive and negative directions. Meters that are specified as capable of measuring only positive energy flow as described in OIML R 46-1, 7.6 shall meet the relevant base mpe requirements of OIML R 46-1, 6.2.2 (Table 3) for positive energy flow. These meters shall also be subjected to reversed energy flow, in response to which 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 min, or the time that the test output would register 10 pulses in the positive energy flow direction, or the time that the primary register would register 2 units of the least significant digit in the positive energy flow direction, whichever is longest.

	For reverse running detent designs that are prone to be affected by heating, the test time shall be extended to 10 min at I_{max}. The order of the test points for initial intrinsic error shall be from lowest current to highest current and then from highest current to lowest current. For each test point, the resulting error shall be the mean of these measurements. For I_{max}, the maximum measurement time shall be 10 min including stabilizing time.
Mandatory test points:	Mandatory test points are specified in Table 4 for positive, negative and reverse flow tests. Tests shall be conducted at a minimum at all applicable test points identified in Table 4. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.

Table 4 - Mandatory test points for the determination of initial intrinsic error test

Current	Power factor	Test point mandatory for:		
		Positive flow	Negative flow	Reverse flow
I_{min}	Unity	**Yes**	No	**Yes**
I_{tr}	Unity	**Yes**	**Yes**	No
	Most inductive (1)	**Yes**	**Yes**	No
	Most capacitive (1)	**Yes**	**Yes**	No
10 I_{tr}	Unity	**Yes**	No	No
	Most inductive (1)	**Yes**	No	No
	Most capacitive (1)	**Yes**	No	No
I_{max}	Unity	**Yes**	**Yes**	**Yes**
	Most inductive (1)	**Yes**	**Yes**	No
	Most capacitive (1)	**Yes**	**Yes**	No
(1) Most inductive or capacitive according to the Rated Operating Conditions in OIML R 46-1, 6.1.				

2.2.2 Starting current

Object of the test:	To verify that the meter starts and continues to operate at I_{st} as given OIML R 46-1, 6.2.3.
Test procedure:	The meter shall be subjected to a current equal to the starting current I_{st}. 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 an intentional delay in measurement after reversal of the 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 OIML R 46-1, 6.2.2 (Table 3). The expected time, τ, between two pulses (period), expressed in seconds, is given by: $$\tau = \frac{3.6 \times 10^6}{m \times k \times U_{nom} \times I_{st}}$$ where:

	k is the number of pulses emitted by the output device of the meter per kilowatt-hour (imp/kWh) or the number of revolutions per kilowatt-hour (rev/kWh); m is the number of elements; U_{nom} is the nominal voltage expressed in volts; and I_{st} is the starting current expressed in amperes. Steps for the test procedure: 1. Start the meter. 2. Allow 1.5 × τ seconds for the first pulse to occur. 3. Allow another 1.5 × τ seconds for the second pulse to occur. 4. Determine the effective time between the two pulses. 5. Allow the effective time (after the second pulse) for the third pulse to occur.
Mandatory test points:	I_{st} at unity power factor

2.2.3 Test of no-load condition

Object of the test:	To verify the no-load performance of the meter given in OIML R 46-1, 6.2.4.
Test procedure:	For this test, there shall be no current in the current circuit. The test shall be performed at 110 % of U_{nom}. For meters with a 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. For demand meters, the value(s) of demand shall not exceed 0.1% of the maximum demand rating. The minimum test period Δt, expressed in hours, shall be $$\Delta t \geq \frac{100 \times 10^3}{b \times k \times m \times U_{test} \times I_{min}}$$ where: b is the base maximum permissible error at I_{min} expressed as a percentage (%) and is taken as a positive value; k is the number of pulses emitted by the output device of the meter per kilowatt-hour (imp/kWh) or the number of revolutions per kilowatt-hour (rev/kWh); m is the number of elements; U_{test} is 110 % of U_{nom} expressed in volts; and I_{min} is the minimum current expressed in amperes. For transformer-operated meters with primary rated registers where the value of k (and possibly U_{nom}) 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). *Note:* As an example, the minimum test period would be 0.42 h (25.3 min) for a class B meter (b = 1.5 %) with the following specifications: k = 1000 imp/kWh, m = 1, U_{nom} = 240 V (so U_{test} = 264 V), and I_{min} = 0.6 A.

2.2.4 Meter constants

Object of the test:	To verify that the relationship between the basic energy register and the used test output(s) complies with the manufacturer's specification as required in OIML R 46-1, 7.4.2.1.
Test procedure:	All registers and pulse outputs that are under legal control must be tested unless a system is in place that guarantees the identical behaviour of all meter constants. If

	the meter is capable of supporting multiple meters constants, tests shall be performed using the minimum and maximum meter constant. The test shall be performed by passing a quantity of energy E through the meter, where E is at least E_{min}, expressed in appropriate units (e.g. Wh): $$E_{min} = \frac{1000 \times R}{b}$$ where: R is the apparent resolution of the basic energy register [(1)] expressed in appropriate units (e.g. Wh); and b is the base maximum permissible error [(2)] expressed as a percentage (%). 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. [(1)] Any means may be used to enhance the apparent resolution R of the basic register, as long as care is taken to ensure that the results reflect the true resolution of the basic register. [(2)] The value of b shall be selected from OIML R 46-1, 6.2.2 (Table 3) according to the chosen test point. The value of b may differ to that applicable for the no-load test.
Allowed effect:	The relative difference shall not be greater than one tenth of the base maximum permissible error.
Mandatory test points:	The test shall be performed at a single arbitrary current $I \geq I_{tr}$.

2.2.5 Test mode for demand meters

Object of the test:	To verify the requirements for demand meters equipped with test mode specified in OIML R 46-1, 7.4.2.2.
Applicability:	This test is only applicable for demand meters equipped with test mode.
Test procedure:	[To be completed]
Allowed effect:	[To be completed]
Mandatory test points:	[To be completed]

2.3 Tests for influence factors

2.3.1 Temperature dependence

Object of the test:	To verify that the temperature coefficient requirements of OIML R 46-1, 6.3.2, and Table 4 are fulfilled.
Test procedure:	For each test point, the error of the meter shall be determined at the reference temperature, at each of the upper and lower ambient temperature limits specified for the meter, and at a sufficient number of other temperatures forming temperature intervals of between 15 °C and 23 °C that span the specified temperature range. Furthermore, for each test point and for each temperature interval given by adjacent upper or lower temperature limits including the reference temperature, the (mean) temperature coefficient, c, expressed as %/°C, shall be determined as follows: $$c = \frac{e_u - e_l}{t_u - t_l}$$ where: e_u and e_l are the errors (expressed as %) at the uppermost and the lowest temperatures respectively in the temperature interval of interest; and t_u and t_l are the uppermost and the lowest temperatures, expressed in °C, respectively in the temperature interval of interest.
Mandatory test points:	For direct connected meters:

	The test shall, at minimum, be performed at PF = 1 and PF = 0.5 inductive and for currents of I_{tr}, 10 I_{tr} and I_{max}. For transformer-operated meters: The test shall, at minimum, be performed at PF = 1 and PF = 0.5 inductive and for currents of I_{tr}, 20 I_{tr} and I_{max}. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.
Acceptance Criteria:	A, except for energy registration, where instead the temperature coefficients shall be within the limits for temperature coefficient for the meter class specified in OIML R 46-1, 6.3.2 and Table 4.

2.3.2 Self-heating

Object of the test:	To verify that the meter is able to carry I_{max} continuously as specified in OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	The test shall be carried out as follows: the voltage circuits shall first be energized at the highest nominal voltage for at least 1 h for class A meters and at least 2 h for meters of all other classes. Then, with the meter otherwise at reference conditions, the maximum current shall be applied to the current circuits. For multi-branch meters, the maximum current and voltage shall be applied to all branches. The cable to be used for energizing the meter shall be made of copper, have a length of 1 m and a cross-section which ensures 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 over any 20-minute period does not exceed 10 % of the base maximum permissible error. The error shift compared to the intrinsic error shall comply with the requirements given in OIML R 46-1, 6.3.2 and Table 5 at all times. If the error shift has not levelled out (so that the variation of error over any 20-minute period does not exceed 10 % of the base maximum permissible error) by the end of the test, the meter shall either be allowed to return to its initial temperature and the entire test repeated at power factor = 0.5 inductive or, if the load can be changed in less than 30 seconds, the error of the meter shall be measured at I_{max} and power factor = 0.5 inductive and it shall be checked that the error shift compared to the intrinsic error complies with the requirements given in OIML R 46-1, 6.3.2 and Table 5.
Acceptance Criteria:	A

2.3.3 Load balance

Object of the test:	To verify that the error shift due to load balance complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Applicability:	This test is only for poly-phase meters and for single-phase three-wire meters.
Test procedure:	The error of the meter with current in one current circuit only shall be measured and compared to the intrinsic error at balanced load. During the test, reference voltages shall be applied to all voltage circuits.
Mandatory test points:	The test shall be performed for all current circuits at PF = 1and PF = 0.5 inductive, and, at minimum, for currents of 10 I_{tr} and $I_{max.}$. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some

	additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.
Acceptance Criteria:	A

2.3.4 Voltage variation

Object of the test:	To verify that the error shift due to voltage variations complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	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 poly-phase 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 test points:	The test shall, at minimum, be performed at PF = 1 and PF = 0.5 inductive, for a current of 10 I_{tr}, and at voltages 0.9 U_{nom} and 1.1 U_{nom}. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.
Acceptance Criteria:	A

2.3.5 Frequency variation

Object of the test:	To verify that the error shift due to frequency variations complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	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. If several f_{nom} values are stated, the test shall be repeated with each f_{nom} value.
Mandatory test points:	The test shall, at minimum, be performed at PF = 1 and PF = 0.5 inductive, for a current of 10 I_{tr} for directive connected meters or 20 I_{tr} for transformer-operated meters, and at frequencies of 0.98 f_{nom} and 1.02 f_{nom}. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.
Acceptance Criteria:	A

2.3.6 Harmonics

2.3.6.1 Harmonics in voltage and current

Object of the test:	To verify that the error shift due to harmonics complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	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 test shall be performed using the quadriform and peaked waveforms specified in Table 4 and Table 5 respectively. The amplitude of a single harmonic shall not be more than 0.12 U_1/h for voltage and I_1/h for the current, where h is the harmonic number and U_1 and I_1 are the respective fundamentals. Plots of the current amplitude for the waveforms in Table 4 and Table 5 are shown in Figure 1 and Figure 2 respectively. The r.m.s. current may not exceed I_{max}, i.e. for Table 4, the fundamental current component I_1 may not exceed 0.93 I_{max}. The peak value of the current may not exceed 1.4 I_{max}, i.e. for Table 5, the fundamental current component I_1 (r.m.s.) may not exceed 0.568 I_{max} Harmonic amplitudes are calculated relative to the amplitude of the fundamental frequency component of the voltage or current respectively. Phase angle is

	calculated relative to the zero-crossing of the fundamental frequency voltage or current component respectively.
Mandatory test points:	The test shall, at minimum, be performed at 10 I_{tr}, PF = 1, where the power factor is given for the fundamental component. Note: For the calculation of the combined maximum error as defined in OIML R 46-1, Annex C it may be required by national or regional authorities to implement some additional test points to cover the power factor range of at least of 0.5 inductive to 0.8 capacitive over the current range of at least I_{min} to I_{max}.
Acceptance Criteria:	A

Table 5 – 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	14 %	0°	1.7 %	180°
11	9 %	0°	1.0 %	180°
13	5 %	0°	0.8 %	180°

Table 6 – Peaked waveform

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	14 %	180°	1.7 %	0°
11	9 %	180°	1.0 %	0°
13	5 %	0°	0.8 %	180°

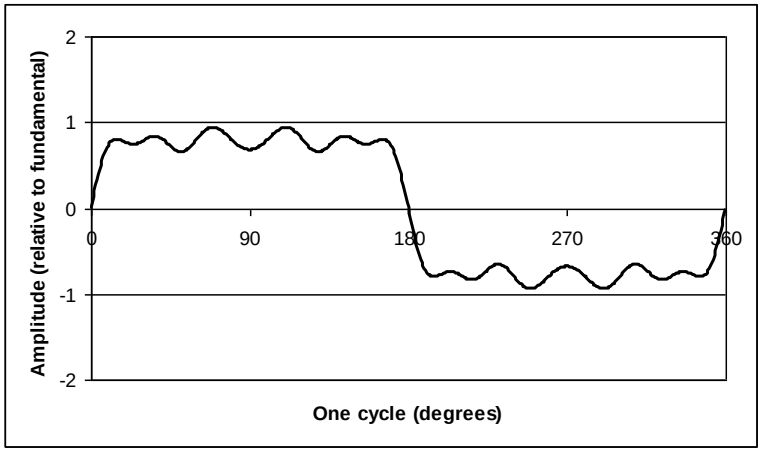

Figure 1 – Current amplitude for quadriform waveform

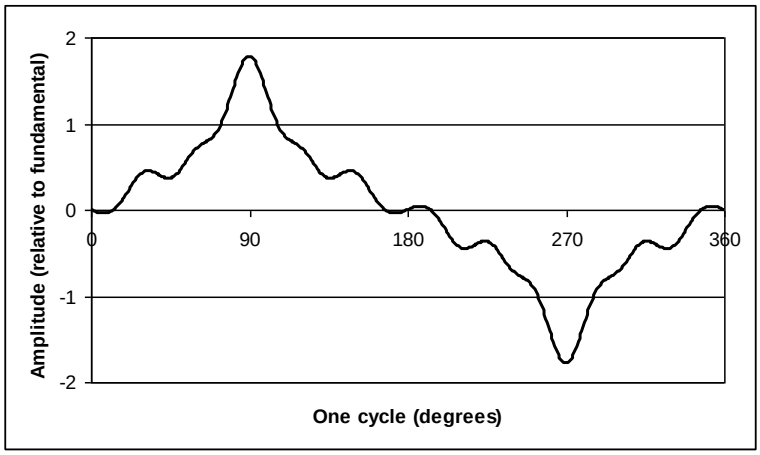

Figure 2 – Current amplitude for peaked waveform

2.3.6.2 Integral cycle load control test

Object of the test:	To verify that the error shift due to sub-harmonics complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	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 3. (The measured power should then be the same as for the original sinusoidal signal while the r.m.s. 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 shall not exceed 1.4 I_{max}.
Mandatory test points:	The test shall, at minimum, be performed at a reference current of 10 I_{tr}, PF = 1.
Acceptance Criteria:	A

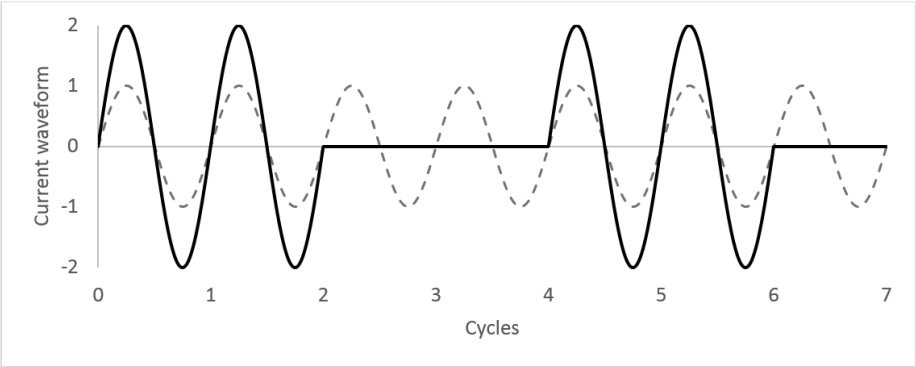

Figure 3 - Test current waveform for the integral cycle load control test

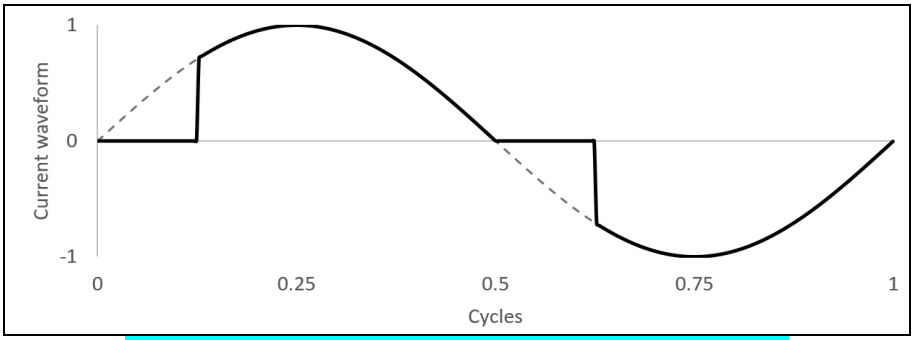

Figure 4 - 45° phase fired waveform (odd harmonics)

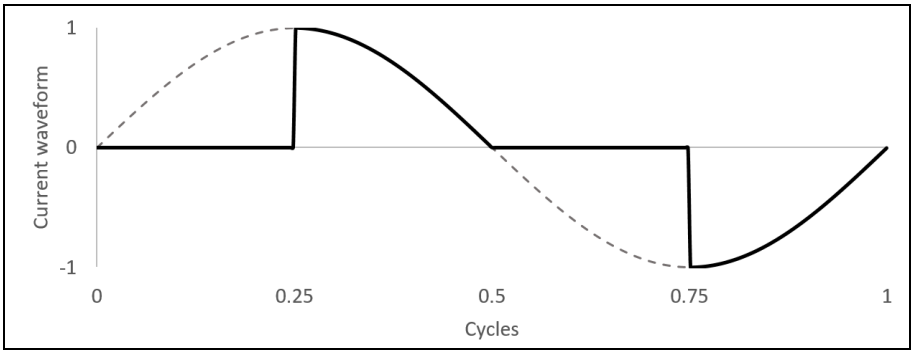

Figure 5 - 90° phase fired waveform (odd harmonics)

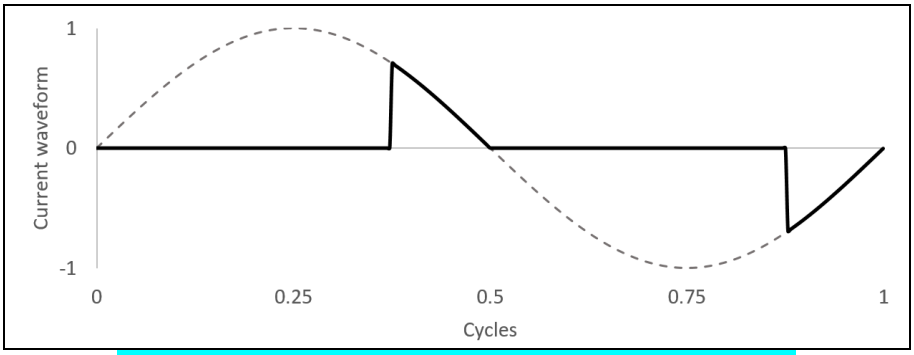

Figure 6 - 135° phase fired waveform (odd harmonics)

2.3.6.3 Odd harmonics in the AC current circuit

Object of the test:	To verify that the error shift due to odd harmonics in the AC current circuit complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured when the sinusoidal reference current is replaced by: a) 45° phase fired waveform shown in Figure 4

	b) 90° phase fired waveform shown in Figure 5 c) 135° phase fired waveform shown in Figure 6 The rise time of the leading edge of the phase fired waveforms shall be 0.2 ms ± 0.1 ms.
Mandatory test points:	The test shall, at minimum, be performed at a reference current of 10 I_{tr}, PF = 1. Additional test points may be specified by national authorities.
Acceptance Criteria:	A

2.3.6.4 High-order harmonics

Object of the test:	To verify that the error shift due to high-order harmonics complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure:	The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured when asynchronous test signals, swept from f = 15 f_{nom} to 40 f_{nom}, are superimposed first on the signal to the voltage circuits and then on the signal to the current circuits. In the case of a poly-phase meter all voltage or current circuits may be tested at the same time. The signal frequency shall be swept from low frequency to high frequency and back down while the metering error is measured.
Test severity:	The asynchronous signal shall have a value of 0.02 U_{nom} and 0.1 I_{tr}, with a tolerance of ± 5 %.
Mandatory test points:	The test shall be performed at I_{tr}. One reading shall be taken per harmonic frequency.
Acceptance Criteria:	A

2.3.6.5 DC in the AC current circuit

Object of the test:	To verify that the error shift due to DC in the AC current circuit complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Applicability:	This test is only for direct-connected meters.
Test procedure:	The error shift, compared to the intrinsic error at sinusoidal conditions at $I = I_{max}/2\sqrt{2}$, shall be measured when the current amplitude is increased to twice its value ($I = I_{max}/\sqrt{2}$) and is half-wave rectified.
Mandatory test points:	The test shall be performed at PF = 1.
Acceptance Criteria:	A

Note 1: The half-wave rectification and measurement can be performed as shown in Figure 7 (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.

Note 2: 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 1 % of the AC component, the instrument should preferably be calibrated beforehand by a measurement of the test current with the test circuit diodes disconnected and short-circuited.)

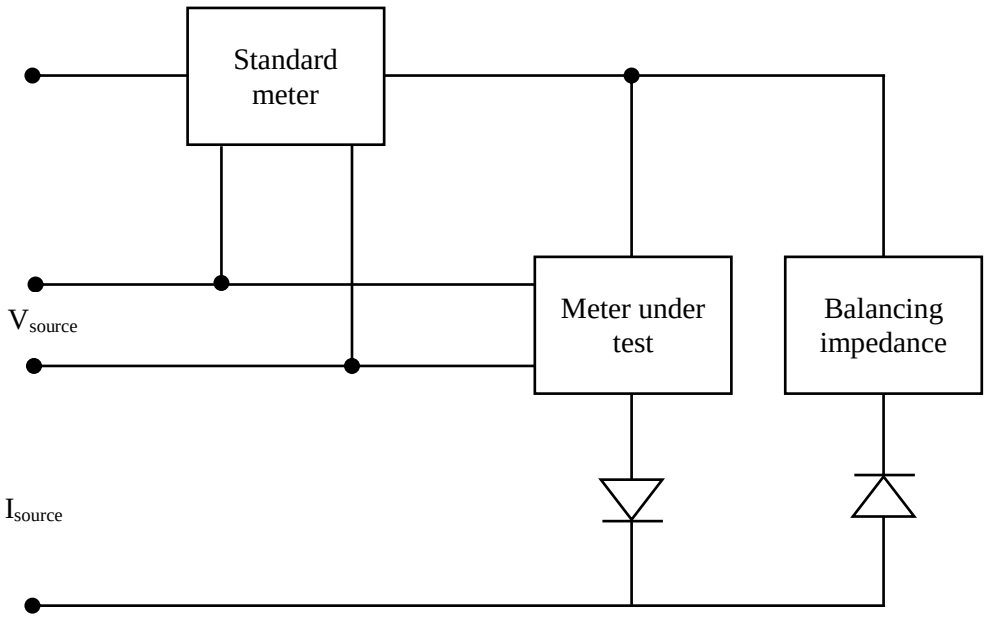

Figure 7 - Proposed current test circuit for DC and even harmonic test (only one-phase current circuit shown, voltage to be connected as normal)

2.3.7 Reversed phase sequence (any two phases interchanged)

Object of the test:	To verify that the error shift due to interchanging any two of the three phases complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Applicability:	This test is only for three-phase meters.
Test procedure:	The error shift, compared to the intrinsic error at reference conditions, shall be measured when any two of the three phases are interchanged.
Mandatory test points:	The test shall, at minimum, be performed at a reference current of 10 I_{tr}, PF = 1 with any two of the three phases interchanged. Additional test points may be specified by national authorities.
Acceptance Criteria:	A

2.3.8 Magnetic field (AC, power frequency) of external origin

Applicable standard:	IEC 61000-4-8 [15]
Object of the test:	To verify that the error shift due to an AC magnetic field at power frequency complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure in brief:	The meter shall be in operating condition with voltage circuits and auxiliary power circuits energised with their lowest specified nominal voltages. A magnetic induction of external origin produced by a current of the same frequency as that of the voltage applied to the meter voltage circuits and flowing through the inductive coil shall be applied in the most unfavorable conditions of phase and direction compared to the voltage(s) energizing the meter. After the test position of the EUT has been determined, the test duration shall be 1 min.
Test severity:	Immersion test method, continuous magnetic field applied in three perpendicular planes, field strength 0.5 mT (400 A/m)
Mandatory test points:	The test shall be performed at 10 I_{tr}, PF = 1.
Acceptance Criteria:	A

2.3.9 Electromagnetic fields

2.3.9.1 Radiated, radio frequency (RF), electromagnetic fields

Applicable standard:	IEC 61000-4-3 [11] or IEC 61000-4-20 [20]
Object of the test:	To verify that the error shift due to radiated, radio frequency, electromagnetic fields complies with the requirements of OIML R 46-1, 6.3.2 and Table 5. Note, test condition 2 below corresponds to the disturbance test of 2.4.8.
Test procedure in brief:	The error shift, compared to the intrinsic error at sinusoidal conditions, shall be measured when the meter is subjected to electromagnetic RF fields. The electromagnetic field strength shall be as specified by the severity level and the field uniformity shall be as defined by the standard referenced. 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 cable length exposed to the electromagnetic field shall be 1 m. The test shall be performed with the generating antenna facing each side of the meter (front, back, left and right). When the meter can be used in different orientations (i.e. vertical or horizontal) all sides shall be exposed to the fields during the test. The carrier shall be modulated with 80 % AM at 1 kHz sine wave. Any sensitive frequencies shall be analyzed separately. *Note:* Usually these sensitive frequencies can be expected to be the frequencies emitted by the meter. The meter shall be tested as a table-top instrument under two test conditions, where test condition 2 corresponds to the disturbance test of 2.4.8:
Test condition 1:	During the test, the meter shall be energized with reference voltage and a current equal to 10 I_{tr}. The measurement error of the meter 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 error at each 1 % incremental interval of the carrier frequency shall be monitored and compared to the requirements of OIML R 46-1, 6.3.2 and Table 5. When using a continuous frequency sweep, this can be accomplished by adjusting the ratio of the sweep time and the time of each measurement. When using incremental 1 % frequency steps, this can be accomplished by adjusting the dwell time on each frequency to fit the measurement time. Refer to Annex A for information on dwell time.
Acceptance Criteria:	A
Test condition 2:	During the test, the voltage and auxiliary circuits of the meter shall be energized with reference voltage. There should be no current in the current circuits and the current terminals shall be open-circuited. *Note:* Test condition 2 corresponds to the disturbance test of 2.4.8, therefore the acceptance criteria specified in 2.4.8 applies.
Test severity:	As defined in Table 7.

Table 7 – Test severities for radiated, radio frequency (RF), electromagnetic fields tests

For test condition	Frequency range	Field strength
Test condition 1 (with current)	80 MHz to 2.0 GHz	10 V/m
	2.0 GHz to 6 GHz	3 V/m
	80 MHz to 2.0 GHz	30 V/m

Test condition 2 (without current)	2.0 GHz to 6 GHz	10 V/m

2.3.9.2 Immunity to conducted disturbances, induced by radiofrequency fields

Applicable standard:	IEC 61000-4-6 [14]
Object of the test:	To verify that the error shift due to conducted disturbances, induced by RF fields complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure in brief:	A radiofrequency electromagnetic current to simulate the influence of electromagnetic fields shall be coupled or injected into the power ports and I/O ports of the meter using coupling/decoupling devices as defined in the standard referenced. The performance of the test equipment consisting of an RF generator, (de)coupling devices, attenuators, etc. shall be verified. The meter shall be tested as a table-top instrument. During the test, the meter shall be energized with reference voltage and a current equal to 10 I_{tr}. The error at each 1 % incremental interval of the carrier frequency shall be monitored and compared to the requirements of OIML R 46-1, 6.3.2 and Table 5. When using a continuous frequency sweep, this can be accomplished by adjusting the ratio of the sweep time and the time of each measurement. When using incremental 1 % frequency steps, this can be accomplished by adjusting the dwell time on each frequency to fit the measurement time. Refer to Annex A for information on dwell time.
Test severity:	RF amplitude (50 Ohm): 10 V (e.m.f.) Frequency range: 0.15 – 80 MHz Modulation: 80 % AM, 1 kHz sine wave
Acceptance Criteria:	A

2.3.10 Fast load current variation test

Applicable standard:	IEC 62052-11 [21]
Object of the test:	To verify that the error shift due to fast load current variations complies with the requirements of OIML R 46-1, 6.3.2 and Table 5.
Test procedure in brief:	The test current shall be repeatedly switched between on and off states. During the t_{on} period, the value of the test current shall be 10 I_{tr}. During the t_{off} period, the value of the test current shall be zero. The durations of the t_{on} and t_{off} periods shall be according to the following test profiles: 1) t_{on} = 10 s, t_{off} = 10 s, total test duration 4 h. 2) t_{on} = 5 s, t_{off} = 5 s, total test duration 4 h. 3) t_{on} = 5 s, t_{off} = 0.5 s, total test duration 4 h. The turn-off times and the turn-on times need not to be synchronized with the zero crossings of the mains frequency. The switching between on and off states shall occur within one cycle at nominal mains frequency. The tolerance for t_{on} and t_{off} shall be +/- one cycle at nominal mains frequency
Test conditions:	Voltage and auxiliary circuits energized with highest specified reference voltages;
Acceptance Criteria:	A

2.4 Test for disturbances

2.4.1 Magnetic field (AC, power frequency) of external origin

Applicable standard:	IEC 61000-4-8 [15]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of an AC magnetic field at power frequency of external origin.

Test procedure in brief:	The meter shall be connected to the reference voltage but with no current in the current circuits. The magnetic field shall be applied along three orthogonal directions.
Test severity:	Magnetic field strength short duration (3 s): 1000 A/m. Note: 1000 A/m corresponds to a free space magnetic flux density of 1.26 mT.
Acceptance Criteria:	B

2.4.2 Electrostatic discharge

Applicable standard:	IEC 61000-4-2 [10]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of direct and indirect electrostatic discharge.
Test procedure in brief:	An ESD generator shall be used with performance characteristics specified in the referenced standard. Before starting the tests, the performance of the generator shall be verified. At least 10 discharges, in the most sensitive polarity, shall be applied. If sensitivity is not known then at least 10 discharges shall be in both polarities. For a meter not equipped with a ground terminal, the meter shall be fully discharged between discharges. Each of the following tests shall be performed unless not applicable.
Indirect discharge test:	The contact discharge voltage shall be applied to both vertical and horizontal coupling planes in contact mode. In both vertical and horizontal planes, all faces of the meter shall be exposed to the discharge.
Contact discharge test:	The contact discharge voltage shall be applied to conductive parts accessible in normal operation.
Air discharge test:	The air discharge voltage shall be applied to non-conductive parts accessible in normal operation.
Test severity:	Contact discharge voltage: 8 kV Air discharge voltage: 15 kV
Acceptance Criteria:	B

2.4.3 Fast transients

Applicable standards:	IEC 62052-11 [21], IEC 61000-4-4 [12]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions where electrical bursts are superimposed on voltage and current circuits, and I/O and communication ports.
Test procedure:	The test procedure is specified in IEC 62052-11, Fast transient burst test. Testing shall be performed at the values of current and power factor specified below in Mandatory test points.
Test severity:	Test voltage on the current and voltage circuits: 4 kV. Test voltage on signal and auxiliary circuits: 2 kV or 1 kV. Repetition rate: 100 kHz.
Mandatory test points:	10 I_{tr}, PF = 1.
Acceptance Criteria:	A

2.4.4 Severe voltage variations

Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of severe voltage variations.

Test procedure 1:	The intrinsic error shall first be measured at U_{nom}. The error shift, relative to the intrinsic error at U_{nom}, shall be measured 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 poly-phase 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 test points 1:	The test shall, at minimum, be performed at 10 I_{tr}, PF = 1 and for voltages of 0.8 U_{nom}, 0.85 U_{nom} and 1.15 U_{nom}
Test procedure 2:	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.
Mandatory test points 2:	The test shall, at minimum, be performed at 10 I_{tr}, PF = 1 and for voltages of 0.7 U_{nom}, 0.6 U_{nom}, 0.5 U_{nom}, 0.4 U_{nom}, 0.3 U_{nom}, 0.2 U_{nom}, 0.1 U_{nom}, and 0 V. If the meter has a distinct shut-down voltage, then mandatory test points shall include one point above and one point below the shut-down voltage. The lower test point shall be within a 2 V range below the shut-down voltage. The upper test point shall be within a 2 V range above the turn-on voltage.
Acceptance Criteria:	A

2.4.5 One or two phases interrupted

Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of one or two phases interrupted.
Applicability:	The test is only for poly-phase meters with three measuring elements.
Test procedure:	The error shift, compared to the intrinsic error at balanced voltage and load current conditions, shall be measured when one or two of the phases are removed while keeping the load current constant. Two phases interrupted is only for those connection modes where a missing phase means that energy can be delivered. A poly-phase meter which is powered from only one of its phases shall not have the voltage of that phase interrupted for the purposes of this test.
Mandatory test points:	The test shall, at minimum, be performed at 10 I_{tr}, with one or two of the phases removed in combinations such that each phase has been removed at least once.
Acceptance Criteria:	A

2.4.6 Continuous (DC) magnetic induction of external origin

Applicable standard:	None.
Object of the test:	To verify that the error shift due to continuous (DC) magnetic induction of external origin complies with the requirements of OIML R 46-1, 6.4.2 and Table 6.
Test procedure:	The error shift, compared to the intrinsic error at reference conditions, shall be measured when the meter is subjected to continuous magnetic induction with a probe in the form of a permanent magnet with a surface area of at least 2000 mm^2. The magnetic field along the axis of the magnet's core shall comply with details specified in Table 13[(1)]. [(1)] National authorities may select a lower magnetic induction for national requirements. Note: Neodymium or niobium permanent magnets are recommended for this test.
Mandatory test points:	6 points per meter surface. The test shall, at minimum, be performed at 10 I_{tr}, PF = 1. The greatest error shift is to be noted as the test result.
Acceptance Criteria:	A

Table 13 - Specifications of the field along axis of the magnet's core

Distance from magnet surface	Magnetic induction	Tolerance

0 mm	400 mT	± 10 mT

2.4.7 Voltage dips and interruptions

Applicable standards:	IEC 62052.11 [21], IEC 61000-4-11 [16]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of short time mains voltage reductions (dips and interruptions).
Test procedure:	The test procedure is specified in IEC 62052.11, AC voltage dips and short interruptions. This test is conducted without any current in the current circuits.
Acceptance Criteria:	B

2.4.8 Radiated, radio frequency (RF), electromagnetic fields

Applicable standard:	IEC 61000-4-3 [11] or IEC 61000-4-20 [20]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of radiated, radio frequency, electromagnetic fields.
Test procedure:	Refer to 2.3.9.1 for test procedure, under test conditions 2.
Acceptance Criteria:	B

2.4.9 Surges on AC mains power lines

Applicable standard:	IEC 61000-4-5 [13]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 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 specified in the referenced 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 referenced standard. The characteristics of the generator shall be verified before connecting the meter.
Test Conditions:	Meter in operating condition; Voltage circuits energized with nominal voltage; Without any current in the current circuits and the current terminals shall be open; Cable length between surge generator and meter: 1 m; Tested in differential mode (line to line); Phase angle: pulses to be applied at 0°, 90°, 180° and 270° relative to zero crossing of AC supply.
Test severity:	Voltage circuits: • Line to line [(1)]: Test voltage: 2.0 kV, generator source impedance: 2 Ω; • Line to earth [(2)]: Test voltage: 4.0 kV, generator source impedance: 2 Ω; • Number of tests: 5 positive and 5 negative; • Repetition rate: maximum 1/min. 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. (1) In meters without PE terminal: 4 kV line to neutral. (2) For cases where the earth of the meter is separate to neutral.
Acceptance Criteria:	B

2.4.10 Damped oscillatory waves immunity test

Applicable standard:	IEC 61000-4-18 [18]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of damped oscillatory waves.
Applicability:	This test is only for meters intended to be operated with external voltage transformers.
Test procedure in brief:	The meter is subjected to damped oscillatory voltage waveforms with a peak voltage according to the test severity stated below.
Test Conditions:	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 an 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).
Mandatory test points:	20 I_{tr}, PF = 1 and 0.5 inductive.
Acceptance Criteria:	A, except the meter function shall not be perturbed during the disturbance.

2.4.11 Short-time overcurrent

Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of a short time overcurrent.
Test procedure in brief:	The meter shall be able to handle the current caused by a short-circuit within the load being metered, when that load is protected with the proper fuses or breakers. With the voltage reconnected the meter shall be allowed to return to normal temperatures (about 1 h). The error shift shall then be measured.
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 0.5 s. The test current shall be applied to one phase at the time. The test current value given is the r.m.s. value, not the peak value.
Mandatory test points:	10 I_{tr}, PF = 1
Acceptance Criteria:	A

2.4.12 Impulse voltage

2.4.12.1 General

Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6 under conditions of impulse voltage.
General test procedure:	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 complete meters. 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 distances between the conductive foil and the terminals, and between the conductive foil and the holes for the conductors, shall be no more than 2 cm. During the impulse voltage test, the circuits that are not under test shall be connected to the earth.
General test conditions:	Ambient temperature: 15 °C to 25 °C; Relative humidity: 25 % to 75 %; Atmospheric pressure: 86 kPa to 106 kPa.
Acceptance Criteria:	B. In addition, during this test no flashover, disruptive discharge or puncture shall occur.

2.4.12.2 Impulse voltage test procedure

Test Conditions:	Impulse waveform: 1.2/50 µs impulse specified in IEC 60060-1 [1]; Voltage rise time: ± 30 %; Voltage fall time: ± 20 %; Source energy: 10.0 J ± 1.0 J; Test voltage: in accordance with Table 8; Test voltage tolerance: +0 –10 %; Source impedance: 500 Ω ± 50 Ω. For each test (see 2.4.12.3 and 2.4.12.4) 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 30 s.

Table 8 – Impulse voltage test levels

Voltage phase to earth derived from rated system voltage (V)	Rated impulse voltage [1]	
	Minimum	Maximum
V ≤ 100	1.5 kV	3 kV
100 < V ≤ 150	3 kV	6 kV
150 < V ≤ 300	4 kV	10 kV
300 < V ≤ 600	6 kV	12 kV

(1) The minimum values are the default (standard) values. A national authority may select higher values up the maximum values.

2.4.12.3 Impulse voltage tests for circuits and between circuits

Test procedure:	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.

2.4.12.4 Impulse voltage tests of electric circuits relative to earth

Test procedure:	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

2.4.13 Earth fault

Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of earth fault.
Applicability:	This test only applies to 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.
Test procedure:	The following test 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 8). In this way, the two voltage terminals of the meter under test which are not affected by the earth fault are connected to 1.9 times the nominal phase voltages.

	The error shift shall be measured when the meter is back at nominal working temperature.
Mandatory test points:	10 I_{tr}, power factor = 1, balanced load.
Acceptance Criteria:	A

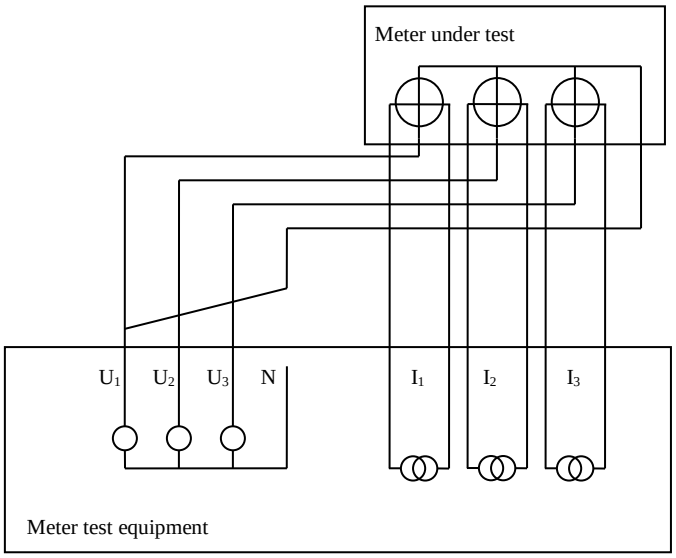

Figure 8 - Set-up for earth fault test

2.4.14 Operation of auxiliary devices

Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of operation of auxiliary devices. The operation of auxiliary devices shall be tested to ensure that they do not affect the metrological performance of the meter.
Test procedure:	In this test, the meter shall be operated at reference conditions and its error continuously monitored, while auxiliary devices such as communication devices, relays and other I/O circuits are operated.
Mandatory test points:	I_{tr} and I_{max} at PF = 1.
Acceptance Criteria:	A

2.4.15 Mechanical tests

2.4.15.1 Vibrations

Applicable standards:	IEC 62052.11 [21], IEC 60068-2-6 [4]
Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of vibrations.
Test procedure:	The test procedure is specified in IEC 62052.11 [21] Vibration test. Testing shall be performed at the values of current and power factor specified below in Mandatory test points.
Mandatory test points:	10 I_{tr}, PF = 1.
Acceptance Criteria:	A, except that supply and load control switches are allowed to change state during the disturbance.

2.4.15.2 Shock

Applicable standards:	IEC 60068-2-27 [5]

Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of shock.
Test procedure in brief:	The meter is subjected to non-repetitive shocks of standard pulse shapes with specified peak acceleration and duration. During the test, the meter shall not be operational and it shall be fastened to a fixture or to the shock-testing machine.
Test severity:	Pulse shape: half-sine Peak acceleration: 30 g_n (300 ms^{-2}) Pulse duration: 18 ms
Mandatory test points:	10 I_{tr}, PF = 1.
Acceptance Criteria:	A, except that supply and load control switches are allowed to change state during the disturbance.

2.4.16 Protection against solar radiation

Applicable standards:	ISO 4892-3 [24]
Object of the test:	To verify compliance with the requirements of OIML R 46-1, 6.4.2 and Table 6, 7.1.1, 7.2, and 7.4.1 regarding protection against solar radiation.
Applicability:	This test is for outdoor meters only.
Test apparatus:	Lamp type/wavelength: UVA 340; Black panel thermometer; Light meter; Cycling rig with a condensation cycle to comply with the parameters in the test conditions.
Test conditions:	Meter in non-operating condition.
Test procedure in brief:	Partially mask a section of the meter for later comparison. Expose the meter to artificial radiation and weathering in accordance with ISO 4892-3 [24] for a period of 66 days (132 cycles) and in accordance with the test conditions above.
Acceptance Criteria:	B. In addition, after the test the meter shall be visually inspected. The appearance and, in particular, the legibility of markings and displays shall not be altered. Any means of protection of the metrological properties, such as the case and sealing, shall not be affected.

Test cycle (12 h cycle)	Lamp type	Spectral irradiance	Black panel temperature
8 h dry	UVA 340	0.76 $W \cdot m^{-2} \cdot nm^{-1}$ at 340 nm	60 ± 3 °C
4 h condensation		Light off	50 ± 3 °C

2.4.17 Climatic tests

2.4.17.1 Extreme temperatures – dry heat

Applicable standard:	IEC 60068-2-2 [3], IEC 60068-3-1 [8]
Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of dry heat.
Test procedure in brief:	The test consists of exposure to the specified high temperature under “free air” conditions for 2 h (beginning from when the temperature of the meter is stable), with the meter in a non-operating state.

	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 upper temperature limit specified for the meter.
Possible temperatures:	40 °C 55 °C 70 °C 85 °C.
Mandatory test points:	10 I_{tr}, PF = 1.
Acceptance Criteria:	A

2.4.17.2 Extreme temperatures – cold

Applicable standard:	IEC 60068-2-1 [2], IEC 60068-3-1 [8]
Object of the test:	To verify compliance with the provisions of OIML R 46-1, 6.4.2 and Table 6 under conditions of low temperatures.
Test procedure in brief:	The test consists of exposure to the specified low temperature under "free air" conditions for 2 h (beginning from the time when the temperature of the meter is stable) with the meter in a non-operating state. 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 lower than the lower temperature limit specified for the meter.
Possible temperatures:	–10 °C –25 °C –40 °C –55 °C(1).
Mandatory test points:	10 I_{tr}, PF = 1.
Acceptance Criteria:	A

Note (1): If specified lower temperature limit is –55 ºC, then this test shall be performed at –55 ºC.

2.4.17.3 Damp heat, steady-state (non-condensing), for humidity class H1

Applicable standard:	IEC 60068-2-78 [7], IEC 60068-3-4 [9]
Object of the test:	To verify compliance with the provisions in OIML R 46-1, 6.4.2 and Table 6 under conditions of high humidity and constant temperature.
Applicability:	This test is for meters that are specified for enclosed locations where the meters are not subjected to condensed water, precipitation, or ice formations (H1).
Test procedure in brief:	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 meter shall be handled such that no condensation of water occurs on it.
Test 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.
Acceptance Criteria:	A 24 h after the test the meter shall be submitted to a functional test during which it shall be demonstrated to operate correctly. There shall be no evidence of any mechanical damage or corrosion which may affect the functional properties of the meter.

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

Applicable standard:	IEC 60068-2-30 [6], IEC 60068-3-4 [9]

Object of the test:	To verify compliance with the provisions in OIML R 46-1, 6.4.2 and Table 6 under conditions of high humidity and temperature variations.
Applicability:	This test applies to meters with a humidity class specification either for enclosed locations where meters can be subjected to condensed water or for open locations (humidity classes H2 and H3).
Test procedure in brief:	The test consists of exposure to cyclic temperature variation between 25 °C and the temperature specified as the upper temperature according to the test severities below, whilst maintaining the relative humidity above 95 % during the temperature change and low temperature phases, and at 93 % during the upper temperature phases. Condensation should occur on the meter 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 reduced 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 meter are within 3 °C of their final temperature.
Test conditions:	Voltage and auxiliary circuits energized with reference voltage; Without any current in the current circuits; Mounting position according to manufacturer's specification.
Test severities:	Meters with a humidity class specification for enclosed locations where meters can be subjected to condensed water shall be tested at severity level 1. Meters with a humidity class specification for open locations shall be tested at severity level 2.

Specified humidity class:	**H2**	**H3**
Severity levels:	1	2
Upper temperature (°C):	40	55
Duration (cycles):	2	2

Acceptance Criteria:	A 24 h after the test the meter shall be submitted to a functional test during which it shall be demonstrated to operate correctly. There shall be no evidence of any mechanical damage or corrosion which may affect the functional properties of the meter.

2.4.18 Durability test

Object of the test:	To verify compliance with the provisions in OIML R 46-1, 6.4.2, Table 6 and 6.5 for durability.
Test procedure in brief:	The test procedure for durability shall be taken from an appropriate standard for durability, e.g. IEC 62059-32-1 [23]
Mandatory test points:	For initial and final measurement, the voltage shall be U_{nom}, with the following test points: I_{tr}, 10 I_{tr}, and I_{max} at PF = 1.
Acceptance Criteria:	A

2.4.19 Ring wave test

Applicable standard:	IEC 61000-4-12 [17], IEC 62052-11 [21]

Object of the test:	To verify compliance with the provisions in OIML R 46-1, 6.4.2 and Table 6 for ring waves.
Test procedure in brief:	The test procedure is specified in IEC 62052-11, Ring wave.
Acceptance Criteria:	B

2.4.20 Conducted differential mode current disturbances (2-150 kHz)

Applicable standard:	IEC 62052.11 [21], IEC 61000-4-19 [19]
Object of the test:	To verify compliance with the provisions in OIML R 46-1, 6.4.2 and Table 6 for differential mode current disturbances.
Test procedure in brief:	The test is performed with disturbances in the current only with the test conditions and severities specified below.
Test conditions:	Voltage circuits and auxiliary power supply circuits energised with their lower specified nominal voltage. For poly-phase meters, the voltage shall be balanced, with a single-phase load. Each phase shall be tested one by one, unless the meter metrology design is identical in all three phases.
Test severity:	The differential test current I_{diff} shall be applied to: a) Mains port of direct connected meters: i) 2 kHz to 30 kHz: I_{diff} = 3 A ii) 30 kHz to 150 kHz: I_{diff} = 1.5 A b) Current transformer port of transformer-operated meters: i) 2 kHz to 30 kHz: $I_{diff} = 0.03 \times I_{max}$ ii) 30 kHz to 150 kHz: $I_{diff} = 0.015 \times I_{max}$ c) Using test wave profiles “CW (Continuous Wave) pulses with pause” and “rectangular modulated pulses” (IEC 61000-4-19:2014 [19], 5.2.2 and 5.2.3) d) With a tolerance for I_{diff} of ± 5% e) Frequency step shall be 1 % f) Dwell time as specified in Annex A.
Mandatory test points:	10 I_{tr} at PF = 1
Acceptance criteria:	A, except for the indicating display function, which shall be evaluated according to criteria B.

2.5 Tests for technical requirements

2.5.1 Internal clocks

Applicable standard:	IEC 62054-21:2004-05 [22], clause 7.5
Object of the test:	To verify compliance with the provisions in OIML R 46-1, 7.9 for timekeeping accuracy requirements for internal clocks.
Test procedure in brief:	The timekeeping accuracy of the internal clock is determined under conditions of mains supply and operation reserve. These tests are performed for synchronous and/or crystal-controlled clocks. Crystal-controlled clocks are also tested at high and low temperature.
Test conditions:	For synchronous clocks: a) Mains supply, 23 °C, 30 days b) Operation reserve, 23 °C, 36 hours For crystal-controlled clocks: a) Mains supply, 23 °C, 30 days b) Operation reserve, 23 °C, 36 hours c) High temperature, 45 °C, 24 hours d) Low temperature, −10 °C, 24 hours
Acceptance criteria:	Time-keeping errors are within limits specified in IEC 62054-21:2004-05 [22], clause 7.5.

2.5.2 Evaluation of software-controlled meters

Evaluation procedures for software-controlled meters are provided in Annex C.

2.5.3 Tests for demand meters

[To be added – based on OIML R 46-1, 7.7]

2.5.4 Tests for interval and multi-tariff meters

[To be added – based on OIML R 46-1, 7.8]

2.6 Test for kinds of meters

2.6.1 Tests for multi-branch meters

Test procedures for multi-branch meters are provided in Annex B.

2.6.2 Tests for street-light meters

[To be added – based on OIML R 46-1, 8.2]

3 Verification

3.1 General

Verification may be carried out either individually or statistically. In all cases, meters shall conform to the requirements of this Recommendation. As noted in OIML R 46-1, 6.2.2, national authorities may specify the base maximum permissible errors for subsequent verification and in-service inspections. The following minimum program applies to the initial verification of all meters, whether verified individually or statistically, and to re-verification of meters which have been repaired or otherwise changed. For individual or statistical re-verification of meters that have not been repaired or otherwise changed, the program may be modified and further reduced.

The exact requirements for verification and in-service inspection shall be specified by the national authority.

3.2 Testing

3.2.1 Calibration status

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

3.2.2 Conformity check

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

Note: This is distinct from conformity to type. Refer to OIML D 34 *Conformity to Type (CTT) – Pre-market conformity assessment of measuring instruments* [26] for more information.

3.2.3 Warming-up

It may be necessary to warm the meter up before full operation. The length of the warming-up period depends on the actual type of instrument and shall be determined in advance. During the test for initial intrinsic error the meter shall be allowed to stabilize at each current level before measurements for a period, no longer than 5 min, to be nominated by the manufacturer. The order of the test points shall be from lowest current to highest current and then from highest current to lowest current. For each test point, the resulting error shall be the mean of these measurements. For I_{max}, the maximum measurement time shall be 10 min including stabilizing time.

3.2.4 Minimum test program

The minimum program consists of:

- No-load check;
- Starting current check;
- Current dependence;
- Check of the register.

3.2.4.1 No-load check

For this test, there shall be no current in the current circuit. The test shall be performed at U_{nom}.

For meters with a 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 Δt shall be as specified in 2.2.3.

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

For transformer-operated meters with primary rated registers where the value of k (and possibly U_{nom}) 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).

3.2.4.2 Starting current check

The test is performed at I_{st} and unity power factor.

For initial verification of meters produced from a continuously operating process resulting in a large number of identical units, it is sufficient for the error curve from I_{st} to I_{min} to be recorded on a sample batch every 3 months for the particular meter type.

For initial verification of meters produced by other means, it will be sufficient if the meter is observed to run continuously when the starting current is applied (refer to the test procedure in 2.2.2).

A meter with more than one connection mode shall be tested in all modes. However, if the test is made *in-situ* on an installed meter, only the actual mode of connection need be tested.

3.2.4.3 Current dependence

Meters shall comply with the accuracy requirements (base maximum permissible errors) of OIML R 46-1, 6.2.2 and Table 3. As a minimum these shall be checked at the following currents:

- I_{min}, PF = 1;

- I_{tr}, PF = 1;
- I_{tr}, PF = 0.5 inductive;
- 10 I_{tr}, PF = 1;
- 10 I_{tr}, PF = 0.5 inductive;
- I_{max}, PF = 1;
- I_{max}, PF = 0.5 inductive.

In the case of three-phase meters with an alternative single-phase connection mode or which are being used as two-phase meters, the single-phase load test shall be performed separately for each phase at:

- 10 I_{tr}, PF = 1; and
- 10 I_{tr}, PF = 0.5 inductive.

For meters with alternate connection modes, such as one-phase connections for poly-phase meters or meters being used as two-phase meters, this test shall be performed separately for each connection mode.

3.2.4.4 Check of the register

If test (pulse) outputs are used for tests of accuracy requirements, a test must be performed to ensure that the relation between the basic energy register and the relevant test output(s) complies with that specified by the manufacturer.

The test shall be performed by passing a quantity of energy E through the meter, where $E \geq E_{min}$ specified in 2.2.4:

The energy put through the meter shall be calculated using the number of pulses from the test output; the relative difference between this energy and the energy registered shall be determined. This relative difference must not be greater than one tenth of the base maximum permissible error.

The test shall be performed at a single arbitrary current $I \geq I_{tr}$.

If the meter is capable of supporting multiple meters constants, tests shall be performed using the minimum and maximum meter constant.

3.2.5 Sealing

If there are no seals on the meter (e.g. because they have not yet been applied or because they have been removed during verification testing), the meter shall be sealed in accordance with the requirements specified by national authorities.

3.3 Reference conditions for initial and subsequent verifications in a laboratory

Reference conditions and load conditions for initial and subsequent verifications in a laboratory are given in Table 9 and Table 10. National authorities may specify tighter tolerances.

Table 9 - Reference conditions and their tolerances for initial and subsequent verification

Quantity	Reference conditions	Tolerance
Voltage(s)	U_{nom}	± 2 %
Ambient temperature	23 ºC	± 5 ºC
Frequency	f_{nom}	± 0.5 %
Wave-form	Sinusoidal	d ≤ 2 %
Magnetic induction of external origin at reference frequency	0 T	B ≤ 0.1 mT
Electromagnetic RF fields 30 kHz – 6 GHz	0 V/m	< 2 V/m
Operating position for instruments sensitive to position	Mounting as stated by manufacturer	± 3.0º
Phase sequence for poly-phase meters	L1, L2, L3	-
Load balance	Equal current in all current circuits	± 5 % and ± 5º

Table 10 – Load conditions and their tolerances in tests for initial and subsequent verification

Current(s)	Current range of device under test	± 10 %
Power factor	Power factor range of device under test	current to voltage phase difference ± 5º

3.4 Additional requirements for statistical verifications

This section contains additional requirements for verification on a statistical basis.

Note: National authorities shall determine whether the use of statistical methods is permitted.

3.4.1 Lot

A lot shall consist of meters with homogeneous characteristics. All meters that comprise the lot shall correspond to the same type approval, and shall have the same year of manufacture.

3.4.2 Samples

Samples shall be randomly taken from a lot.

3.4.3 Statistical testing

The statistical control shall be based on attributes. The sampling system shall ensure:

- An Acceptance Quality Level (AQL) of not more than 1 %; and
- A Limiting Quality (LQ) of not more than 7 %.

The AQL is the maximum percentage of non-conforming items in a lot at which the lot has a probability of 95 % to be accepted.

The LQ is the percentage of non-conforming items in a lot at which the lot has a maximum probability of 5 % to be accepted.

Note: These requirements allow for substantial freedom in the verification program. Examples are given below based on a lot of 1000 meters.

Number of meters tested	40	70	100	1000
Maximum number of non-conforming meters.	0	1	2	10

3.5 Additional requirements for statistical in-service inspections

Guidance for in-service inspections of utility meters is available in OIML G 20 *Surveillance of utility meters in service on the basis of sampling inspections* [27].

Annex A
Dwell time for EMC tests
(Mandatory)

A.1 General

The dwell time is the period during which an influence quantity (either a disturbance or influence factor) is applied at a specific frequency. Where the meter under test is exposed to the electromagnetic influences or disturbances by sweeping through the frequency band, the dwell time at each frequency step shall not be less than 3 s.

A.2 Dwell time for immunity tests while in operation and current flow

The dwell time may be extended as necessary to perform a stable verification of the meter accuracy. The manufacturer shall specify the number of test pulses necessary for the verification of accuracy, or an alternative and equivalent method of verification of accuracy.

The specified number of test pulses from the test optical output shall be measured during the dwell periods to obtain the meter error at each frequency step. If necessary, further investigation may be conducted by exposing the meter to the influence quantity for a longer dwell time per frequency step at frequencies where indication of susceptibility is discovered.

A.3 Dwell time for immunity tests while in operation and without current flow

During tests without any current flowing through the meter no test pulses are generated and consequently, the meter's accuracy cannot be verified at each frequency step. Therefore, the frequency sweep shall be done using the dwell time of 3 s. The content of the meter's energy registers shall be examined before and after the frequency sweep to determine whether any change has occurred.

At the frequency steps where indication of susceptibility is discovered, further investigation may be conducted by exposing the meter to the influence quantity for a minimum of 1 minute per frequency step and determining the change in the energy registers. This change, extrapolated to a period of time of one hour, shall not exceed the critical change value.

Note 1: For example, a polyphase meter, having 3×230/400 V and 100 A maximum current, has a critical change value of $3\times230\times100\times10^{-6} = 0.069$ kWh. At a certain frequency during 1 minute an energy registration of 0.004 kWh is recorded, which is equal to $0.004 \times 60 = 0.24$ kWh for a period of 1 hour. This exceeds the critical change value and therefore the requirement is not fulfilled.

Note 2: A method of "discovering indication of susceptibility" is left to the expertise of the testing laboratory. Generally, it is not necessary to know the exact frequency where the susceptibility occurs – it is sufficient to identify the range of frequencies. It is assumed that the test is stopped at the first failure.

Annex B
Test Procedures for multi-branch meters
(Mandatory)

B.1 Overview

This annex contains additional test procedures that apply for multi-branch meters.

B.2 Type Approval

B.2.1 Single-phase connections

This test is applicable if the meter is designed to measure single-phase connections.

The testing authority shall randomly select one single phase channel, and apply the determination of initial intrinsic test (2.2.1) to the multi-branch meter configured as a single-phase meter with this channel.

B.2.2 Three-phase connections

This test is applicable if the meter is designed to measure three-phase connections.

The testing authority shall randomly select one group of three channels, and apply the determination of initial intrinsic test (2.2.1) to the multi-branch meter configured as a three-phase meter with these channel.

B.2.3 Cross-channel influences

The purpose of this test is to determine whether the performance of the multi-branch meter on one channel is affected by the presence of signals in other channels.

The meter shall be fully connected. That is, energy shall be flowing in every channel, unless no load condition is specified. The accuracy of the meter on one channel shall comply with the base maximum permissible errors for the accuracy class under the following conditions. Under the condition of no load, the no load test shall be performed (see 2.2.3).

The test points and condition are specified in Table 11. For example, when the test channel is loaded with minimum current, power factor 1, the other channels shall be loaded with maximum current and each of the power factors 1, 0.5 inductive and 0.8 capacitive.

Table 11 – Cross-channel influence test conditions

Test channel		Other channels	
Current	**Power Factor**	**Current**	**Power factor**
No load	Not applicable	Maximum current	1, 0.5 inductive, and 0.5 capacitive
Minimum current	1		
Minimum current	0.5 inductive		
Minimum current	0.8 capacitive		

B.2.4 Configurations

The national authority shall determine a limited number of branches that are representative of all configurations (including worst-case configurations) of the multi-branch meter. One of these configurations shall be used when subjecting the multi-branch meter to all (applicable) type approval tests.

In addition, the following tests shall be performed on the multi-branch meter when configured in each of the other representative configurations.

1) All tests for compliance with maximum permissible errors (2.2).
2) All test for influence factors (2.3).

B.2.5 Family of LPITs

If the multi-branch meter is designed to operate with a family of LPITs, with identical characteristics, but different primary current values, the following tests shall be performed on the additional types of LPITs within the family:

1) Determination of initial intrinsic error (2.2.1)
2) Starting current (2.2.2)
3) Test of no-load condition (2.2.3).

B.3 Verification for multi-branch meters

The following verification tests are applicable for multi-branch meters:

a) If the meter is intended to measure single phase connections, the verification tests (3) shall be performed on every single-phase channel on the meter.

b) If the meter is intended to measure three phase connections, the verification tests (3) shall be performed on every group of three phase channels on the meter. Note, if the meter is designed to allow flexibility in how to group three channels, this could result in a very large number of combinations. For example, there are 59 640 combinations of three channels for a 72 channel meter. In this case, it is sufficient to tests a subset of the combinations – typically each set of sequential groups of three channels (1, 2, 3), (4, 5, 6) and so on.

Annex C
Software evaluation for software-controlled meters (Mandatory)

The software evaluation procedure concerns an evaluation of compliance with the requirements as described in OIML R 46-1, Annex B, and comprises a combination of analysis and validation methods and tests as shown in Table 12. The explanation of the abbreviations used and the relation to the methods as described in detail in OIML D 31 [25] is shown in Table Y.2.

Table 12 – Software validation procedures applicable for verification of compliance with the software requirements

Requirement (OIML R 46-1, Annex B)		Evaluation procedure (see Table 13)
B.2.1	Software identification	AD + VFTSw
B.2.2	Correctness of metrological algorithms and functions	AD + VFTSw / VFTM
B.2.3	Software securing and protection	AD + VFTSw
B.2.4	Audit trails	AD + VFTSw
B.2.5	Prevention of misuse	
B.2.6	Support of fault and defect detection	AD + VFTSw / VFTM
B.3.1.2	Separation of constituents of a measuring system	AD
B.3.1.3	Separation of software modules	AD
B.3.1.4	Shared indications	AD + VFTSw
B.3.3.2	Protection of stored data	AD + VFTSw
B.3.3.3	Automatic storage	AD + VFTSw / VFTM
B.3.3.4	Deletion of stored data	AD + VFTSw
B.3.4.2	Protection of transmitted data	AD + VFTSw
B.3.4.3	Transmission delay or interruption	AD + VFTSw
B.3.5	Indications from dynamic modules of legally relevant software	AD + VFTSw

Table 13 – Cross references of evaluation procedures to those described in OIML D 31

Abbreviation	Description	OIML D 31:20XX Subclause
AD	Analysis of the documentation and validation of the design	(7.3.2.1)
VFTM	Validation by functional testing of metrological functions	(7.3.2.2)
VFTSw	Validation by functional testing of software functions	(7.3.2.3)

Annex D
Bibliography
(Informative)

Ref.	Standards and reference documents	Description
[1]	IEC 60060-1 ed 3.0 (2010) High-voltage Test Techniques. Part 1: General Definitions and Test Requirements	This part of IEC 60060 is applicable to: – dielectric tests with direct voltage; – dielectric tests with alternating voltage; – dielectric tests with impulse voltage; – dielectric tests with combinations of the above.
[2]	IEC 60068-2-1 (2007) Environmental testing – Part 2-1: Tests – Test A: Cold	Deals with cold tests applicable to both non heat-dissipating and heat-dissipating specimens. For non heat-dissipating specimens, Tests Ab and Ad do not deviate essentially from earlier issues. Test Ae has been added primarily for testing equipment that requires being operational throughout the test, including the conditioning periods. The object of the cold test is limited to the determination of the ability of components, equipment or other articles to be used, transported or stored at low temperature. Cold tests cover by this standard do not enable the ability of specimens to withstand or operate during the temperature variations to be assessed. In this case, it would be necessary to use IEC 60068-2-14.
[3]	IEC 60068-2-2 (2007) Environmental testing – Part 2-1: Tests – Test B: Dry heat	Deals with dry heat tests applicable both to heat-dissipating and non heat-dissipating specimens. For non heat-dissipating specimens, Tests Bb and Bd do not deviate essentially from earlier issues. The object of the dry heat test is limited to the determination of the ability of components, equipment or other articles to be used, transported or stored at high temperature. These dry heat tests do not enable the ability of specimens to withstand or operate during the temperature variations to be assessed. In this case, it would be necessary to use IEC 60068-2-14 Test N: Change of temperature.
[4]	IEC 60068-2-6 (2007) Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)	Gives a method of test which provides a standard procedure to determine the ability of components, equipment and other articles, hereinafter referred to as specimens, to withstand specified severities of sinusoidal vibration.
[5]	IEC 60068-2-27 Ed. 4.0 (2008) Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock	Provides a standard procedure for determining the ability of a specimen to withstand specified severities of non-repetitive or repetitive shocks. The purpose of this test is to reveal mechanical weakness and/or degradation in specified performances, or accumulated damage or degradation caused by shocks.
[6]	IEC 60068-2-30 (2005) Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)	Determines the suitability of components, equipment or other articles for use, transportation and storage under conditions of high humidity - combined with cyclic temperature changes and, in general, producing condensation on the surface of the specimen.
[7]	IEC 60068-2-78 (2001)	Provides a test method for determining the suitability of electrotechnical products, components or equipment for

	Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state	transportation, storage and use under conditions of high humidity. The test is primarily intended to permit the observation of the effect of high humidity at constant temperature without condensation on the specimen over a prescribed period.
[8]	IEC 60068-3-1 Ed 2.0 (2011-08) Environmental testing – Part 3-1: Supporting documentation and guidance – Cold and dry heat tests	Provides guidance regarding the performance of cold and dry heat tests.
[9]	IEC 60068-3-4 (2001) Environmental testing – Part 3-4 – Supporting documentation and guidance – Damp heat tests	Provides the necessary information to assist in preparing relevant specifications, such as standards for components or equipment, in order to select appropriate tests and test severities for specific products and, in some cases, specific types of application. The object of damp heat tests is to determine the ability of products to withstand the stresses occurring in a high relative humidity environment, with or without condensation, and with special regard to variations of electrical and mechanical characteristics. Damp heat tests may also be utilized to check the resistance of a specimen to some forms of corrosion attack.
[10]	IEC 61000-4-2 (2008) Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	Relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. Additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures. The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.
[11]	IEC 61000-4-3 (2010) Electromagnetic compatibility (EMC). Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	Applies to the immunity of electrical and electronic equipment to radiated electromagnetic energy. Establishes test levels and the required test procedures. Establishes a common reference for evaluating the performance of electrical and electronic equipment when subjected to radio-frequency electromagnetic fields.
[12]	IEC 61000-4-4 (2012) Electromagnetic compatibility (EMC). Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity tests	Establishes a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/burst on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.
[13]	IEC 61000-4-5 (2017) Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques - Surge immunity test	Relates to the immunity requirements, test methods, and range of recommended test levels for equipment with regard to unidirectional surges caused by over-voltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment.
[14]	IEC 61000-4-6 (2013)	Relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances

	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	coming from intended radio-frequency (RF) transmitters in the frequency range 150 kHz up to 80 MHz.
[15]	IEC 61000-4-8, Ed. 2.0 (2009-09) Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	Relates to the immunity requirements of equipment, only under operational conditions, to magnetic disturbances at power frequency related to: – residential and commercial locations; – industrial installations and power plants; and – medium voltage and high voltage sub-stations.
[16]	IEC 61000-4-11 (2020) Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase	Defines the immunity test methods and range of preferred test levels for electrical and electronic equipment connected to low-voltage power supply networks for voltage dips, short interruptions, and voltage variations. This document applies to electrical and electronic equipment having a rated input current not exceeding 16 A per phase, for connection to 50 Hz or 60 Hz AC networks.
[17]	IEC 61000-4-12 (2017) Electromagnetic Compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test	Relates to the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, to ring waves occurring in low-voltage power, control and signal lines supplied by public and non-public networks. The object of this document is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to ring waves.
[18]	IEC 61000-4-18 (2019) Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques - Damped oscillatory wave immunity test	Relates to the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, with regard to: a) repetitive slow damped oscillatory waves occurring mainly in power, control and signal cables installed in high voltage and medium voltage (HV/MV) substations; b) repetitive fast damped oscillatory waves occurring mainly in power, control and signal cables installed in gas insulated substations (GIS) and in some cases also air insulated substations (AIS) or in any installation due to high-altitude electromagnetic pulse (HEMP) phenomena.
[19]	IEC 61000-4-19 (2014) Electromagnetic compatibility (EMC) – Part 4-19: Testing and measurement techniques – Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports	Relates to the immunity requirements and test methods for electrical and electronic equipment to conducted, differential mode disturbances and signalling in the range 2 kHz up to 150 kHz at a.c. power ports. The object of this standard is to establish a common and reproducible basis for testing electrical and electronic equipment with the application of differential mode disturbances and signalling to a.c. power ports.
[20]	IEC 61000-4-20 (2010) Electromagnetic compatibility (EMC) - Part 4-20: Testing and measurement techniques - Emission and immunity testing in transverse electromagnetic (TEM) waveguides	Emission and immunity test methods for electrical and electronic equipment using various types of transverse electromagnetic (TEM) waveguides

[21]	IEC 62052-11, Edition 2, 2020-06 Electricity metering equipment – General requirements, tests and test conditions – Part 11: Metering equipment	Specifies requirements and associated tests, with their appropriate conditions for type testing of AC and DC electricity meters.
[22]	IEC 62054-21:2004-05 Electricity metering equipment (AC) – Tariff and load control – Part 21: Particular requirements for time switches	Specifies particular requirements for newly manufactured indoor time switches with operation reserve that are used to control electrical loads, multi-tariff registers and maximum demand devices of electricity metering equipment.
[23]	IEC 62059-32-1 (2011) Electricity metering equipment - Dependability – Part 32-1: Durability – Testing of the stability of metrological characteristics by applying elevated temperature	Specifies a method for testing the stability of metrological characteristics of electricity meters, by operating a test specimen at the upper limit of the specified operating range of temperature, voltage and current for an extended period.
[24]	ISO 4892-3 (2016) Plastics Methods of exposure to laboratory light sources Part 3: Fluorescent UV lamps	Specifies methods for exposing specimens to fluorescent UV radiation, heat and water in apparatus designed to simulate the weathering effects that occur when materials are exposed in actual end-use environments to global solar radiation, or to solar radiation through window glass.
[25]	OIML D 31 (20XX) General requirements for software controlled measuring instruments	Guidance to OIML Technical Committees and Subcommittees for establishing appropriate requirements for software-related functionalities in measuring instruments covered by OIML Recommendations.
[26]	OIML D 34 (2019) Conformity to Type (CTT) – Pre-market conformity assessment of measuring instruments	Provides considerations for countries and economies, or Regional Legal Metrology Organisations (RLMOs), that are planning to develop conformity to type (CTT) programs in the field of legal metrology. This Document also provides illustrative examples of CTT programs currently in operation.
[27]	OIML G 20 (2017) Surveillance of utility meters in service on the basis of sampling inspections	Relates to the method and procedure according to which the period of validity of the verification of utility meters forming part of a defined lot is extended if the correctness of the utility meters has been proved by sampling inspections prior to the expiry of the period of validity of the verification.