Test specification code: GRI-GRI-TST-E&C-0001

Version no. 1 dated 14/04/2023

Subject: GSSMC001 **-** Tests and Test conditions of static meters

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Enel Grids*

CONTESTS

Test specification code: GRI-GRI-TST-E&C-0001

Version no. 1 dated 14/04/2023

Subject: GSSMC001 **-** Tests and Test conditions of static meters

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Enel Grids*

THE HEAD OF GLBOBAL NETWORK DEVICES

Pilar Nieto Hernandez

Test specification code: GRI-GRI-TST-E&C-0001

Version no. 1 dated 14/04/2023

Subject: GSSMC001 **-** Tests and Test conditions of static meters

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Enel Grids*

1 DOCUMENT AIMS AND APPLICATION AREA

This document describes the Type Tests to be carried out on the static meters of a remote meter reading system for low voltage supplied customers.

In the following the single-phase meter and the poly-phase meters will be identified as CE.
The Type Tests have the scope to check the compliance of the meters with the requirements based on the IEC CEI EN product standards and some additional requirements related to environmental compatibility specifications (electromagnetic, climatic, and mechanical). Therefore, this document has to be considered as the guideline for Type Test, as it introduces, in some cases, requirements more severe than those included in the standards.

All the requirements defined by CEI EN 50470-1, CEI EN 50470-3, IEC 62052-11, IEC 62053-21, related to active energy meters, IEC 62053-23 related to reactive energy meters, as well as Safety standard IEC 62052-31, shall be considered as mandatory even if not explicitly mentioned.

This document shall be implemented and applied to the extent possible within the Enel Grids Business Line and in compliance with any applicable laws, regulations and governance rules, including any stock exchange and unbundling-relevant provisions, which in any case prevail over the provisions contained in this document.

1.1 RELATED DOCUMENTS TO BE IMPLEMENTED AT COUNTRY LEVEL

This document doesn't require implementation of further documents.

Anyway, each Enel Grids Company can issue, under the supervision of Enel Grids Global Network Devices a detailed document, according to the provisions of the present document and in case of specific needs.

2 DOCUMENT VERSION MANAGEMENT

Version	Date	Main changes description
1	14/04/2023	Issuing of "GSSMC001 **-** Tests and Test conditions of static meters" Test specification

3 UNITS IN CHARGE OF THE DOCUMENT

Responsible for drawing up the document:

- Enel Grids: Engineering and Construction / Components and Devices Design / Network Devices unit.

Responsible for authorizing the document:

- Enel Grids: Head of Network Devices unit.
- Enel Grids: Head of Quality unit.

4 REFERENCES

- Integrated Policy for Quality, Health and Safety, Environment, anti-Bribery and Information security.
- ISO 9001- Quality Management System – Requirements.
- ISO 14001 - Environmental Management System - Requirements with guidance for use.
- ISO 45001 - Occupational Health and Safety Management System - Requirements with guidance for use.
- ISO 37001 - Anti-bribery Management System - Requirements with guidance for use.
- ISO 27001 - Information Security Management System – Requirements.
- CEI UNI EN ISO/IEC 17025 - General requirements for the competence of testing and calibration laboratories.
- CEI EN 50065-1 - Signalling on low voltage electrical installation in the frequency range 3 kHz to 148 kHz – Part 1: General requirements, frequency band and electromagnetic disturbances.
- CEI EN 50065-2-3 - Signalling on low voltage electrical installation in the frequency range 3 kHz to 148 kHz – Part 2-3:Immunity requirements for mains communications equipment and systems operating in the range of frequency 3kHz to 95 kHz and intended for use by electricity utilities and distributors.
- CEI EN 60068-1 - Basic environmental testing procedures- Part 1: General and guidance.
- CEI EN 60068-2-1 - Basic environmental testing procedures – Part 2: Tests - Test A: Cold (Ad test).
- CEI EN 60068-2-2 - Basic environmental testing procedures – Part 2: Tests - Test B: Dry heat (Test Bd).
- CEI EN 60068-2-5 - Environmental testing Part 2: Tests - Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing.
- CEI EN 60068-2-6 - Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal).

- CEI EN 60068-2-14 - Basic environmental testing procedures – Part 2: Tests -Test N: Change of temperature (Nb test).
- CEI EN 60068-2-27 - Environmental testing – Part 2: Tests – Test Ea and guidance: Shock.
- CEI EN 60068-2-14 - Environmental testing- Part 2-14: Tests – Test N: Change of temperature.
- CEI EN 60068-2-30 - Environmental testing – Tests - Test Db: Damp heat, cyclic (12h + 12h cycle).
- CEI EN 60068-2-75 - Environmental testing – Part 2: Tests – Test Eh: Hammer tests – Test Ehb: Spring hammer.
- CEI EN 60068-3-1 - Environmental testing - Part 3-1: Supporting documentation and guidance – Cold and dry heat tests.
- CEI EN 60068-3-4 - Supporting documentation and guidance Damp heat tests.
- CEI EN 60068-3-5 - Environmental testing – Part 3-5: Supporting documentation and guidance – Confirmation of the performance of temperature chambers.
- CEI EN 60068-3-7 - Environmental testing – Part 3-7: Supporting documentation and guidance - Measurements in temperature chambers for tests A and B (with load).
- CEI EN 60085 - Thermal evaluation and designation of electrical insulation
- CEI EN 60529 +A1 - Degree of protection provided by enclosures (IP Code).
- CEI EN 60695-2-11 - Fire hazard testing - Part 2-11: Glow-wire based test methods – Glow-wire flammability test methods for end-products (GWEPT).
- CEI EN 61000-4-2 - Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques- Electrostatic discharge immunity tests.
- CEI EN 61000-4-3 + A1 +IS1 +A2 - Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test.
- CEI EN 61000-4-4 - Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test.
- CEI EN 61000-4-5 - Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test.

- CEI EN 61000-4-6 - Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields.
- CEI EN 61000-4-8 - Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test.
- CEI EN 61000-4-9 +A1 - Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques – Section 9 – Pulse magnetic field immunity test – Basic EMC Publication.
- CEI EN 61000-4-11 - Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests.
- CEI EN 61000-4-16 +A1 +A2 - Electromagnetic compatibility (EMC) - Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 KHz.
- CEI EN 61000-4-18 +A1 - Electromagnetic compatibility (EMC) - Part 4-12: Testing and measurement techniques - Oscillatory waves immunity tests.
- CISPR 22 - Limits and methods of measurements of radio disturbance characteristics of information technology equipment, Amendment 1 included.
- IEC 62052-31 - Electricity metering equipment (AC) - General requirements, test and test conditions Part 31: Product safety requirements.
- CEI EN 62053-23 - Electricity metering equipment (a.c.) – Particular requirements. Part 23: Static meter for reactive energy (class 2 and 3).
- CEI EN 62054-21 - Electricity metering (a.c.) - Tariff and load control Part 21: Particular requirements for time switches.
- CEI EN 50470-1 - Electricity metering equipment (AC) – Part 1: General requirements, tests and test condition - Metering equipment (class indexes A, B and C).
- CEI EN 50470-3 - Electricity metering equipment (AC) – Part 3: Particular requirements - Static meter for active energy (class indexes A, B and C).
- CEI EN 62059-41 - Electricity metering equipment – Dependability - Part 41: Reliability prediction.

- CEI EN 62059-32-1 - Electricity metering equipment – Dependability - Part 32-1: Durability - Testing of the stability of metrological characteristics by applying elevated temperature.
- CLC/TR 50570 - Electricity metering equipment (a.c.) – Severity level, immunity requirements and test methods for conducted disturbances in the frequency range 2 kHz – 150 kHz.
- ETSI EN 302 291-1 V1.1.1 - Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Device (SRD); Close Rage Inductive Data Communication equipment operating at 13,56 MHz; Part 1: Technical characteristics and test methods.
- ETSI EN 302 291-2 V1.1.1 - Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Device (SRD); Close Rage Inductive Data Communication equipment operating at 13,56 MHz; Part 2: Harmonized EN under article 3.2 of the R&TTE Directive.
- ASTM D4728-95 - Standard test method for random vibration testing of shipping containers.

Group Pillar References:

- The Code of Ethics of Enel Group.
- The Enel Group Zero Corruption Tolerance Plan (ZTC).
- Human Rights Policy.
- Organization and Management Model as per Legislative Decree No. 231/2001.
- Enel Global Compliance Program (EGCP).

5 ORGANIZATIONAL PROCESS POSITION IN THE PROCESS TAXONOMY

Value Chain/Process Area: Engineering & Construction

Macro Process: Devices and Components Development

Process: Standard Catalog Management

6 ACRONYMS

Acronym and Key words	Description
Equipment Under Test (EUT)	EUT and UUT are manufactured product undergoing testing, either at first manufacture or later during its life cycle as part of ongoing functional testing and calibration checks.
Unit Under Test (UUT)	
Power Line Communication or Power Line Carrier (PLC)	System that carries data on a conductor that is also used simultaneously for AC electric power transmission or distribution.
Distribution Line Carrier (DLC)	System technology used a frequency range of 9 to 500 kHz with data rate up to 576 kbit/s.

7 DESCRIPTION

The Type Tests here described shall be carried out on a representative sample, manufactured using the same components (hardware and software) that will be used for the series production.

Concerning the software aspects, the EUT shall be equipped with all the modules necessary for its operation; if a setting of some operating parameters is foreseen, the most representative for the application shall be used. If such parameters had not yet been defined at the moment of tests, they shall be agreed with Enel Grids.

The equipment submitted to Type Tests shall not be used for other tests or applications.

Before the execution of Type Tests, the manufacturer shall prepare the “Tests Plan“ which shall include the following information:

- applicable documents;
- organization of the Type Test activity;
- tests sequence;
- EUT and auxiliary equipment used to carry out the tests.

The Type Tests shall be carried out inside an ILAC (International Laboratory Accreditation Co-operation) accredited laboratory operating in compliance with CEI UNI EN ISO/IEC 17025, ‘General requirements for the competence of testing and calibration’.

The Type Tests are a contractual constraint for the supplier.

8 TYPE TESTS

8.1 GENERAL REQUIREMENTS

The requirements and Type Tests relate to the static meter fully assembled for normal operating conditions.

In order to speed up the test procedure it is allowed to run parallel test sessions (e.g., climatic tests, EMC tests, etc.). Anyway, all the samples used for the type testing shall be fully representative of the future production in terms of Electronic PCB, mechanical assembly, etc.

Any modification introduced to solve non-conformity issues will be detailed in the test report and will be properly assessed to assure general compliance of the EUT with the specification.

Proposed modifications following the homologation of the product will result in additional testing to be agreed with the Enel Grids. The manufacturer is charged to carry on all the tests provided by the standards CEI EN 50470-1, CEI EN 50470-3 as well as the additional tests here described.

The result of all the tests shall be described in the test report that shall include:

- EUT set up;
- Testing organisation;
- Detailed description of modifications introduced and validated during the tests;
- Detailed modifications introduced and validated after the first homologation.

The test reports shall be submitted by the manufacturer to ENEL Grids.

8.2 TESTS OF THE OPERATING MODES

According to the test plan approved, a detailed test of all the equipment functions, with particular reference to the ones listed below, shall be carried out:

- DLC communication of the CE (using a Data Concentrator Simulator provided by Enel Grids and dedicated SW);
- communication of the CE to dedicated SW via optical interface;
- metering and counting;
- data acquisition and storage;
- time base RTC clock/calendar;
- power quality parameters;
- cut-off device command;
- messages visualization via display;
- self-diagnostics (Status Words);
- permanent magnetic field immunity.

About the verification of the metrological characteristics and performances, the different test conditions specified in the reference standards shall be applied. In case of meter with bi-directional functionality the measurement accuracy and counting shall be checked at relevant operating modes in the four quadrants; for this purpose, the loading conditions normally exercised for mono-directional meters in quadrant 1 and quadrant 4 could be replicated also in quadrant 2 and quadrant 3.

Refer to each test to find out which ones shall be carried out with the CE supplied with the nominal a.c. input voltage and which are not.

8.3 TESTS OF MECHANICAL REQUIREMENTS

8.3.1 Visual Examination

The absence of visible manufacturing defects, the assembly accuracy, and the dimensional compliance, as prescribed by the technical specifications, shall be verified before the execution of the mechanical tests.

Furthermore, it has to be verified that the equipment has been designed and manufactured in such a way to avoid any danger during the normal operations concerning:

- personal safety against electrical shocks;
- personal safety against effects of excessive temperature;
- protection against spread of fire;

And in order to comply with the requirements defined in CEI EN 60529:

- protection of persons against access to hazardous parts inside the enclosure;
- protection of the equipment inside the enclosure against ingress of solid foreign objects;
- protection of the equipment inside the enclosure against harmful effects due to the ingress of water.

8.3.2 Test conditions and acceptance criteria

This testing activity related to the mechanical aspects includes some tests with the EUT in the operating mode and some tests with the EUT non-operating (strength test).

Tests in the operating mode are carried out in order to verify the EUT capability to operate under the test conditions while keeping unchanged the required performances.

The strength tests are carried out in order to verify the EUT capability to tolerate the test stresses without damage, deformations, or degradations such as to adversely affect the operating performances and the personal safety.

TEST	**OPERATING MODE** *In operating mode, the cut-off device shall be closed.*	**NON-OPERATING MODE**
SPRING HAMMER		✕
SHOCK		✕
VIBRATION	✕	
RESISTANCE TO HEAT AND FIRE		✕
PROTECTION AGAINST PENETRATION OF DUST AND WATER		✕

Table 1. Mode of the EUT according to the test in progress.

The EUT shall be installed on the test equipment, with proper fastening devices representing the condition of use; all the tests shall be carried out on the EUT without package.

In order to verify the physical integrity, some inspections shall be carried out before, during and after the tests. The physical integrity shall be considered impaired or not properly assured if any of the following effects are detected:

1. damages or degradations of mechanical, electric, or electronic components;
2. structural distortions or degradations of mechanical parts like housings, support panels, fittings, etc.;
3. fasteners loosening, plugs disengagement;
4. The EUT case shall ensure reasonable safety against spread of fire;
5. Any penetration of dust and water shall be only in a quantity not impairing the operation of the EUT.

After the previous step has been verified, energize the EUT and check that all its functionalities are running.

The strength tests results (not operating mode) are considered acceptable if, after each test, the operating conditions of the EUT are maintained and the physical integrity is preserved.

In addition to the general criteria above-mentioned specific requirements for each test are detailed, where considered necessary.

8.3.3 Spring hammer test

The reference of this test is in the CEI EN 50470-1 standard paragraph 5.2.2.1.

This test is useful to understand the mechanical strength of the EUT case. The test shall be made with a spring hammer (CEI EN 60068-2-75 test Ehb).

With regard to the mode of the EUT for the current test, refer to Table 1.

Before the test, the EUT shall be submitted to the visual, dimensional, and functional checks.

The EUT shall be installed in its normal operating position and the hammer shall act on the outer surfaces of the meter cover, including the reading device, with a kinetic energy of 0.2J ± 0.02J. More in detail the hammer has to test the front side and the 4 lateral faces, not the back one, and the display.

The evaluation of the test results will be made in accordance with the general criteria reported in sub-clause §8.3.2.

The result of the test is satisfactory if the case does not sustain damage which could affect the function of the EUT and is not possible to touch live parts. Minor damages which do not impair the protection against indirect contact, or the penetration of solid objects, dust and water are acceptable (IP protection degrees unchanged).

After the test, the compliance with the technical requirements of EUT shall be verified.

8.3.4 Shock test

The reference of this test is in the CEI EN 50470-1 standard paragraph 5.2.2.2.

The shock test shall be carried out, according to CEI EN 60068-2–27, under following condition:

- EUT in non-operating condition (refer to Table 1);
- half-sine pulse;
- peak acceleration: 30 g_n (300 m/s^2);
- duration of the pulse: 18 ms.

Before the test, the EUT shall be submitted to the visual, dimensional, and functional checks.

The EUT shall be installed in its normal operating position.

The test shall be performed applying #3 shocks in positive direction and #3 negative one, successively in each one of the three axes – reference axes are defined as: horizontal $\hat{x}$ (front → back) $\hat{y}$ (side → side) and vertical $\hat{z}$ (bottom → up).

The evaluation of the test results will be made in accordance with the general criteria reported in sub-

clause 8.3.2.

After the test, the EUT shall not show damages or changes of the stored information; the compliance with the technical requirements shall be verified.

8.3.5 Vibration test

The reference of this test is in the CEI EN 50470-1 standard paragraph 5.2.2.3. The test shall be carried out according to CEI EN 60068-2-6.

The sinusoidal vibration test includes the following steps which shall be carried out in the proposed order:

- Initial investigation of critical frequencies (see 8.3.5.1);
- Endurance test by sweeping (see 8.3.5.2);
- Endurance test at fixed frequency (see 8.3.5.3);
- Endurance test in [100,150]Hz frequency range (see 8.3.5.2);
- Final response investigation of the critical frequencies (see 8.3.5.4).

During all the vibration test, the EUT shall be in operating condition (see Table 1).

In order to control in real-time the evolution of vibration test, two points are considered:

- the first accelerometer is located on the vibration table and it is used to verify that the machine's piston is properly working.
- the second accelerometer is located on the EUT with the specific purpose of recording the dynamic response of the object.

8.3.5.1 Initial investigation of critical frequencies

The investigation of the critical frequencies has the objective to analyse dynamic response of the EUT in order to detect malfunction or mechanical resonance.
This test shall be carried out by a sweep in the frequency range 10 ÷ 150 Hz, along the three EUT main axis. A sweep rate of 0.5 oct/min shall be used.
The stress levels shall be equal or lower than those ones used during the endurance tests, as specified in CEI EN 60068-2-6 §8.2.

Frequency range:		[10 , 150] Hz
Peak Value	**[10 , 57.6] Hz**	± 0.,075 mm (displacement)
	[57.6 , 150] Hz	± 1.0 g_n(1) (acceleration)
Sweep rate		0.5 oct/min
Number of sweeps		1 (10Hz→150Hz→10Hz)
Note 1: g_n: standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude – In the reference standard, the value of g_n results rounded up to the nearest whole number, that is 10 m/s^2.		

Table 2. Test parameters initial investigation of critical frequencies – applicable to whole the three axes.

The critical frequencies are distinguished by:

- malfunctioning and/or degradation of the performances of the EUT dependent on vibration;
- mechanical resonance and/or other response effects, e.g., chatter. The detected resonance frequencies will be considered critical when the dynamic amplification factor is in the range 2 to 3 – this result is the input for the one described in §8.3.5.3.

8.3.5.2 Endurance test by sweeping

The endurance test by sweeping, has the objective to verify the resistance to mechanical fatigue of the EUT. The test provides for sweep cycles in the frequency range, along the three main axis of the object.

Two different ranges are used, each one with its own parameters.

Range [10, 150] Hz
During this test the whole range is involved.

The immunity requirements to comply with are:

- below the cross-over frequency (f < 60 Hz) → displacement amplitude = ±0.075mm (peak value);
- above the cross-over frequency (f > 60 Hz) → acceleration amplitude = 1gn (peak value);

For each axis 10 cycles shall be performed, with a sweep rate of 1 octave per minute.

Since the specificities of the current test:

Frequency range:		[10 , 150] Hz
Peak Value	**[10 , 57.6] Hz**	± 0.075 mm (displacement)
	[57.6 , 150] Hz	± 1.0 g_n (1) (acceleration)
Sweep rate		1 oct/min
Number of sweeps		10 (UP and DOWN – 10Hz→150Hz→10Hz)
Note 1: g_n : standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude – In the reference standard, the value of g_n results rounded up to the nearest whole number, that is 10 m/s^2.		

Table 3. Test parameters endurance test by sweeping [10 , 150]Hz – applicable to whole the three axis.

Note1: n.10 sweep cycles ≈ 75 min.
Note2 the nominal transition frequency is 60 Hz, for this test the actual cross-over (transition) frequency is 57.6 Hz.

Range [100 , 150] Hz
This test is required regardless of the initial investigation's results.
The idea for the current test is to deal the most significant part of the frequency range as a critical one. Therefore, the same conditions described in §8.3.5.3 are applied. This leads to a test harder than the previous one, due to a greater number of sweeps.

Frequency range:		[100 , 150] Hz
Peak value	**[100 , 150] Hz**	± 1.0 g_n (1) (acceleration)
Sweep rate		1 oct/min
Number of sweeps		26 (UP and DOWN)
Note 1: g_n: standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude – In the reference standard, the value of g_n results rounded up to the nearest whole number, that is 10 m/s^2.		

Table 4. Test parameters endurance test at fixed frequencies [100,150]Hz – applicable to whole the three axis.

Note1: Is required that the test lasts 30min, according to what in §8.3.5.3, n.26 sweep cycles shall be performed – for each axis.

Note2: the nominal transition frequency is 60 Hz, for this test the actual cross-over (transition) frequency is 57.6 Hz.

8.3.5.3 Endurance test at fixed frequencies – Critical frequencies

In these tests a sinusoidal excitation is generated, with the same level as required in the endurance test by sweeping, at specified frequencies.

The test frequencies are the critical ones detected in the initial investigation described in sub-clause 8.3.5.1.

The fixed frequencies test can be carried out, instead of at fixed frequency, by mean of a sweep over a range of ± 20% around the central resonance frequency, as prescribed in the procedure “almost fixed frequency” by CEI EN 60068-2-6 sub-clause 8.3.2.

The test duration shall be about 30 minutes for each frequency.
The number of cycles is given by the formula:

$$C = D/T$$

where:

- ***C*** is the number of Cycles for the current test;
- ***D*** is the Duration of the current test [min];
- ***T*** is the Sweep duration for one sweep cycle (up and down) [min].

Knowing, by the CEI EN 60068-2-6 sub-clause A.4.3, that:

$$T = \frac{2\log_e(f_2/f_1)}{SR\log_e(2)}$$

where:

- f_1 is the lower frequency limit of the sweep [Hz];
- f_2 is the upper frequency limit of the sweep [Hz];
- ***SR*** is the sweep rate for the current test [oct/min].

then:

$$C = D\left(\frac{2\log_e(f_2/f_1)}{SR\log_e(2)}\right)^{-1}$$

8.3.5.4 Final response investigation of the critical frequencies

At the end of the endurance test cycles, a comparison between the initial detected frequencies and the final ones shall be made. For this purpose, a sweep shall be performed in the whole frequency range of the test and with the same requirements and vibration amplitudes used in the initial investigation.

Deviations of the critical frequencies greater than 20 % of the value detected in the initial investigation, compromise the final result of the endurance test. Only after the introduction of suitable modifications of the EUT – in order to assure the physical integrity – the test will be repeated.

8.3.5.5 Final measurement

After the test, the EUT shall not show damages or changes of the stored or in use information. The compliance with the technical requirements of the equipment shall be verified.

8.3.6 Test of resistance to heat and fire

The reasonable safety of the EUT against spread of fire shall be verified.

The test procedures, as described in CEI EN 50470-1 at §5.8, shall comply with the requirements defined in CEI EN 60695-2-10, CEI EN 60695-2-11 and with the following conditions:

- Terminal block: 960 °C ± 15 °C;
- Terminal cover and meter case: 650 °C ± 10 °C;
- duration of application: 30 s ± 1 s.

The contact with the glow wire may occur at any random location.

Note: with regard to the mode of the EUT for the current test, refer to Table 1.

The EUT case shall ensure reasonable safety against spread of fire. It should not be ignited by thermal overload of live parts in contact with it.

8.3.7 Test of protection against penetration of dust and water

As required by CEI EN 50470-1, the meter shall conform to the degree of penetration given in CEI EN 60529.The degree of protection prescribed in the meter specification shall be verified. It is briefly summarized below:

- IP54: electronic board;
- IP54: department in which are enclosed current sensor;
- IP20: terminal block.

The Meter is designed to be an indoor meter. Therefore, according to the aforementioned standards, it shall conform to the degree of protection IP54.

The test procedures shall comply with the requirements defined in CEI EN 60529 and with the following conditions.

a) Protection against penetration of dust (the following indications are relative to the first digit IP 5X):

- Meter in non-operating condition (refer to Table 1) and mounted on an artificial wall;
- the test should be conducted with sample lengths of cable of the max cross-section admitted. In order to avoid sealing the exposed ends, it is suggested to use the cable to connect input and output terminals. The terminal cover shall be in place;
- for indoor meters only, the same atmospheric pressure is maintained inside the meter as outside (neither under- nor over-pressure);

Any penetration of dust shall be only in a quantity not impairing the operation of the Meter. An insulation test shall be passed.

b) Protection against penetration of water (the following indications are relative to the second digit IP X4):

- meter in non-operating condition (refer to Table 1);

Any penetration of water shall be only in a quantity not impairing the operation of the meter. An insulation test shall be passed.

8.4 TESTS OF CLIMATIC INFLUENCES

For all the tests covered in this section, refer to the CEI EN 50470-1 chapter 6.

8.4.1 Climatic conditions

The climatic conditions for the Meter are defined in terms of range of temperature and relative humidity. These two parameters refer to the operating, storage or transport conditions according to the following definitions:

- **Rated operating conditions**: set of specified measuring ranges for performance characteristics and specified operating ranges for influence quantities, within which the variations or operating errors of a CE are specified and determined.
- **Specified operating range**: range of values of a single influence quantity which forms a part of the rated operating conditions.
- **Limit range of operation**: extreme conditions which an operating meter can withstand without damage and without degradation of its characteristics when it is subsequently operated under its rated operating conditions.

  Note: The requirements for the operating functions, applicable in the limit range, are detailed in each climatic test procedure.

- **Storage and transport conditions**: extreme conditions which a non-operating CE can withstand without damage and without degradation of its characteristics when it is subsequently operated under its rated operating conditions.

The temperature range shall be as shown in the following table.

Climatic requirements	
Specified operating range	-40°C to +70°C
Limit range of operation	-40°C to +70°C
Limit range for storage and transport	-40°C to +70°C

Table 5. Climatic requirements

The relative humidity requirements are reported in the following table and characterised by the frequency of occurrence.

Annual mean	< 75 %
For 30 days, spread in a natural manner over one year	95 %
Occasionally on other days	85 %

The compliance with the temperature and humidity requirements shall be verified by means of the climatic tests described in following sub-clauses of the current paragraph.

8.4.2 Test procedure and acceptance criteria

The tests shall be carried out on the equipment installed inside the climatic test chamber, in the condition of use and ready to operate.

The auxiliary equipment used for the functional verification of the EUT shall be installed outside the test chamber.

Before starting the climatic test, the operating conditions of the EUT specified in sub-clause 8.2, shall be verified.

The operating conditions of the EUT shall be:

- energised at the reference voltage U_n;
- current value corresponding to the basic current I_b or to the nominal current I_n;
- power factor unity ($\cos\varphi$ =1 for active power, $\text{sen}\varphi$ = 1 for reactive power).

Note: before the test, the EUT shall be kept in normal ambient conditions for 48 hours at least, without protection or package used for transportation.

The test chamber(s) shall be constructed and verified in accordance with specifications CEI EN 60068-3-5 and CEI EN 60068-3-7. It has to comply with the requirements of the international standards that regulate each one of the climatic tests described in this document.

The result of each test is satisfactory if the EUT, during the whole duration of the test, maintains the operating performances defined in the specifications reported in sub-clause 8.2 and the integrity of the physical characteristics.

For the physical characteristics, the EUT shall be visually inspected to verify:

- the preservation of the electrical or mechanical properties of plastic materials;
- the absence of oxidation in the metallic parts (terminals, screws);
- the integrity of treatments and/or coating materials;
- the possible drying of electrolytic capacitors, batteries, etc.;
- the absence of cracking in mechanical devices.

In the case of performances/characteristics partially impaired, the test report shall be filled with information suitable for the final acceptance.

The EUT shall, in any case, restore automatically the operating functions at the end of the exposure time.

All the checks that are required during the climatic tests (excepted the change of temperature one – see sub-clause 8.4.7), shall be performed after the EUT has reached the stability with the ambient test conditions of the chamber. In any case, the time required for the stability is considered to be of at least two hours. Unless, by the test in §8.4.3, does not emerge some different indication.

8.4.3 Thermal analysis

Before the climatic tests, the thermal analysis shall be carried out; the equipment shall be in the operating mode and in the standard atmospheric conditions.

The higher thermal dissipation areas are identified, the temperature values near these components are measured; these values, related with the highest temperature detected during the tests with the EUT operating, shall not exceed the maximum (ambient) temperature values declared by the component manufacturer.

In the identified areas, suitable sensors should be installed in order to monitor the temperatures trend up to the temperature stability.

The thermal analysis will include the recording of the temperature trend in order to identify the EUT thermal time constant that leads to the identification of the time need to reach the thermal stability.

8.4.4 Dry heat test

This test, included in CEI EN 50470-1 (see 6.3.2), shall be carried out in accordance with the conditions and the acceptance criteria of this specification.

The test required by the CEI EN 50470-1 to verify that the EUT works properly, even at high temperatures, is the “Bb” test. However, the “Bd” test is required as it is considered more severe than the “Bb” one.
To evaluate the EUT also by a metrological point of view, a load is required.

The test conditions presented in the following table shall be apply.

Reference standard : CEI EN 60068-2-2 (test Bd)		
Temperature [°C]	**Duration** [h]	**Humidity** [g/m^3]
Specified operating range:+70(1) Limit range of operation:+70(1)	72	20(2)
NOTES: (1) The tolerance is ±2 °C. (2) Absolute humidity corresponding to a relative humidity of 50% at 35 °C. The relative humidity shall not exceed 50%.		

Functional characteristics shall be verified before the test. As well as the metrology, that has to be respect the limits of:

Value of current for direct connected or transformer operated meters	**Power factor**	**Percentage error limits for meters of class index**
		C
$I_{min} \le I \le I_{max}$	1	± 1,0
$I_{tr} \le I \le I_{max}$	0,5 ind…1…cap 0,8	± 0,5
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.		

Table 6. Percentage error limits at reference conditions (single-phase meters and polyphase meters with balanced loads). CEI EN 50470-3

PROCEDURE:

The climatic conditions inside the test chamber shall be raised from the ambient values to the test values and maintained for 72 hours.

After reaching the stability with the ambient, the EUT shall be energised at the condition specified in sub-clause 8.4.2.

During this period, every 24 hours, the EUT 's operations and the functional characteristics, as defined in sub-clause 8.2, shall be verified – without remove the EUT from the chamber.

Limits of additional percentage error due to influence quantities, according to CEI EN 50470-3, are:

8.4.4.1 ACTIVE ENERGY

Influence quantity	**Value of current for direct connected or transformer operated meters**	**Power factor**	**Limits of additional percentage error for meters of class index**		
Temperature variation			**A**	**B**	**C**
5 °C to 30 °C	$I_{min} \le I \le I_{max}$	1	± 1,8	± 0,9	± 0,5
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 2,7	± 1,3	± 0,9
-10 °C to 5 °C 30 °C to 40 °C	$I_{min} \le I \le I_{max}$	1	± 3,3	± 1,6	± 1,0
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 4,9	± 2,3	± 1,6
-25 °C to -10 °C 40 °C to 55 °C	$I_{min} \le I \le I_{max}$	1	± 4,8	± 2,4	± 1,4
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 7,2	± 3,4	± 2,4
-40 °C to -25 °C 55 °C to 70 °C	$I_{min} \le I \le I_{max}$	1	± 6,3	± 3,1	± 1,9
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 9,4	± 4,4	± 3,1
Voltage variation ± 10%	$I_{min} \le I \le I_{max}$	1	± 1,0	± 0,7	± 0,2
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 1,5	± 1,0	± 0,4
Frequency variation ± 2%	$I_{min} \le I \le I_{max}$	1	± 0,8	± 0,5	± 0,2
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 1,0	± 0,7	± 0,2
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.					

Table 7. Limits of additional percentage error due to influence quantities (single-phase meters and polyphase meters balanced loads). CEI EN 50470-3.

8.4.4.2 REACTIVE ENERGY (meters of class 2)

- 0.1% (per °C) at power factor = 1 (see EN 62053-23 – Tab.8);
- 0.15% (per °C) at power factor = 0.5 (see EN 62053-23 – Tab.8).

These intermediate measurements shall be performed every 24h.

At the end of the whole exposure time, the EUT shall be switched off. After that, the ambient conditions inside the chamber shall be restored to the standard atmospheric conditions. 24h after – unless, by the test in §8.4.3, emerge some different indication – when the EUT has attained the temperature stability, the following points shall be verified:

- accuracy requirements;
- operating modes, defined in sub-clause 8.2 of this specification.

8.4.5 Damp heat, cyclic test

This test, included in CEI EN 50470-1 (see 6.3.4), shall be carried out in accordance with the conditions and the acceptance criteria of this specification. The test conditions have to be referred to the CEI EN 60068-2-30 (test Db) and are summarized below:

Reference standard : CEI EN 60068-2-30 (test Db – 12h + 12h cycle – Variant 1)		
Temperature [°C]	**Duration** [cycles]	**Humidity** [g/m^3]
+ 55 (1)(2)	6	Figure 1
NOTES: (1) The tolerance is ±2 °C. (2) it is required to test the meters as outdoor ones, even if they are designed as indoor.		

Functional characteristics shall be verified before the test. Moreover the following tests shall be carry out:

- insulation tests according to the content of the CEI EN 50470-1 at chapter 7.3 (see §8.5.4 of this document);
- metrology check.

The test comprises several temperature cycles in which the relative humidity is maintained at a high level.

No particular precaution have to be taken to remove surface moisture.

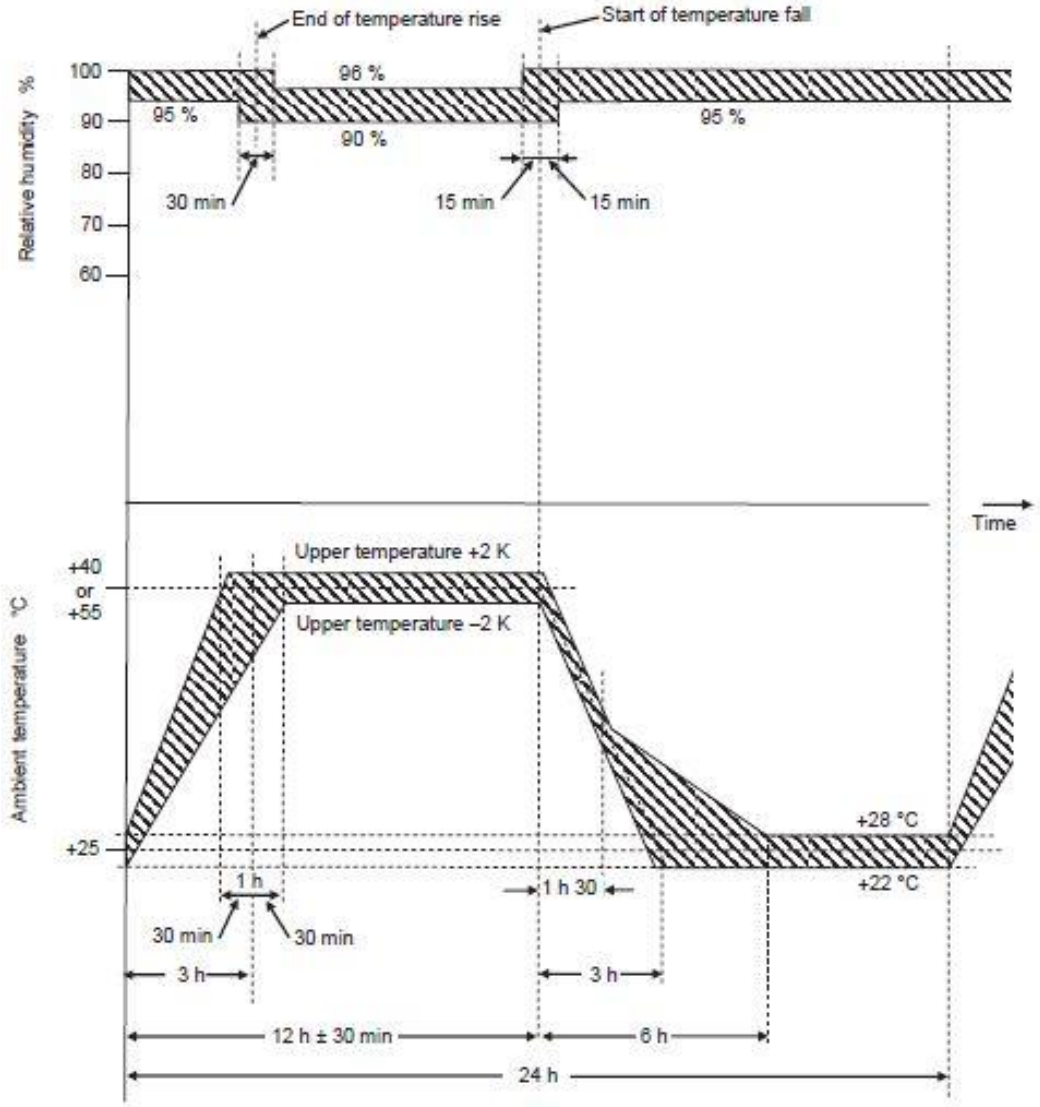


Figure 1. Damp heat – Test cycle

PROCEDURE

In order to start the first cycle, the EUT has to be installed in the chamber, both stabilized at 25 °C ± °C. Than the humidity of the chamber has to be increased to not less than 95% maintaining the ambient temperature of 25 °C ± 3 °C

Description of the 24 h cycle (test profiles illustrating the procedure are shown in Figure 1):

- The temperature of the chamber shall be raised to the appropriate upper temperature +55 °C. The upper temperature shall be achieved in a period of 3 h ± 30 min and at a rate within the limits defined by the shaded areas in Figure 1.

During this period, the relative humidity shall not be less than 95 % RH. During the last 15 min it shall not be less than 90 % RH.
Condensation may occur on the specimen during this temperature-rise period.

- The temperature shall then be maintained within the prescribed limits for the upper temperature (±2 °C) until 12 h ± 30 min from the start of the cycle.
  During this period, the relative humidity shall be 93 % RH ± 3 %RH. During the first and last 15 min it shall be between 90 % RH and 100 % RH.

- The temperature shall be lowered to 25 °C ± 3 °C within 3 h to 6 h. The rate of fall for the first hour and half shall be such that, if maintained as indicated in Figure 1, it would result in a temperature of 25 °C ±3 °C being attained in 3 h ± 15 min.
  The relative humidity shall be not less than 95 % RH. During the first 15 min it shall be not less than 90 % RH.

- The temperature shall then be maintained at 25 °C ± 3 K with a relative humidity of not less than 95 % RH until the 24 h cycle is completed.

Note: for the purpose of the test, the check of the principal functionalities (DLC communication and status word) shall be done day by day; taking care that, at the end of the whole test, both the high temperature and the low temperature have been checked.

After the end of the 6th cycle wait during 24h, then the EUT has to be submitted to the following tests:

1. an insulation test according to the content of the CEI EN 50470-1 at chapter 7.3, except that the impulse voltage has to be multiplied by a factor of 0,8 (see §8.5.4 of this document);
2. a functional test. The EUT has not to show damages or change of the information and it has to work correctly;
3. metrology check.

The damp heat test has also to be intended as a corrosion test. The result will be visually judged. No traces of corrosion, that may affect the functional properties of the EUT, have to be present after the test.

8.4.6 Cold test

This test, included in CEI EN 50470-1 (see 6.3.3) and CEI EN 62052-11 (see 6.3.2), shall be carried out in accordance with the conditions and the acceptance criteria of this specification.
The test conditions presented in the following table shall be apply.

The test required by the CEI EN 50470-1 to verify that the EUT works properly, even at low temperatures, is the “Ab” test. However, the “Ad” test is to be preferred as it is considered more severe than the required one.
To evaluate the EUT also by a metrological point of view, a load is required.

Reference standard : CEI EN 60068-2-1 (Ad test)		
Temperature (°C)	**Duration** (h)	**Humidity**
Specified operating range: -40 (1) Limit range of operation: -40 (2)	24 + 24+ 24	not controlled
NOTES: (1) The tolerance is ±3 °C. (2) The tolerance is ±5 °C.		

Functional characteristics shall be verified before the test as well as the metrology, that has to respect the following limits:

Value of current for direct connected or transformer operated meters	**Power factor**	**Percentage error limits for meters of class index**		
		A	**B**	**C**
$I_{min} \le I \le I_{max}$	1	± 2,5	± 1,5	± 1,0
$I_{tr} \le I \le I_{max}$	0,5 ind…1…cap 0,8	± 2,0	± 1,0	± 0,5
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.				

Table 8. Percentage error limits at reference conditions (single-phase meters and polyphase meters with balanced loads).

PROCEDURE:

The climatic conditions inside the test chamber shall be led from the ambient values to the test values of the specified operating range and maintained for 24 hours: the exposure period starts when the EUT has reached the stability with the ambient test conditions of the chamber.

The EUT shall be maintained in the power off state for 12 hours and then powered on. After power on, with the operating conditions defined in sub-clause 8.4.2, the proper EUT operations shall be verified with reference to the functional characteristics described in sub- clause 8.2.

At the end of this period the climatic conditions inside the test chamber shall be set to the test values for the limit range of operation and maintained for 24 hours. The exposure period starts when the EUT – always energised – has reached the stability with the ambient test conditions of the chamber.

During this period a degradation or interruption of the EUT's functionality can be accepted. In this condition the CE measuring function shall be maintained with a reduced accuracy.

The following ranges of error are admitted:

8.4.6.1 ACTIVE ENERGY

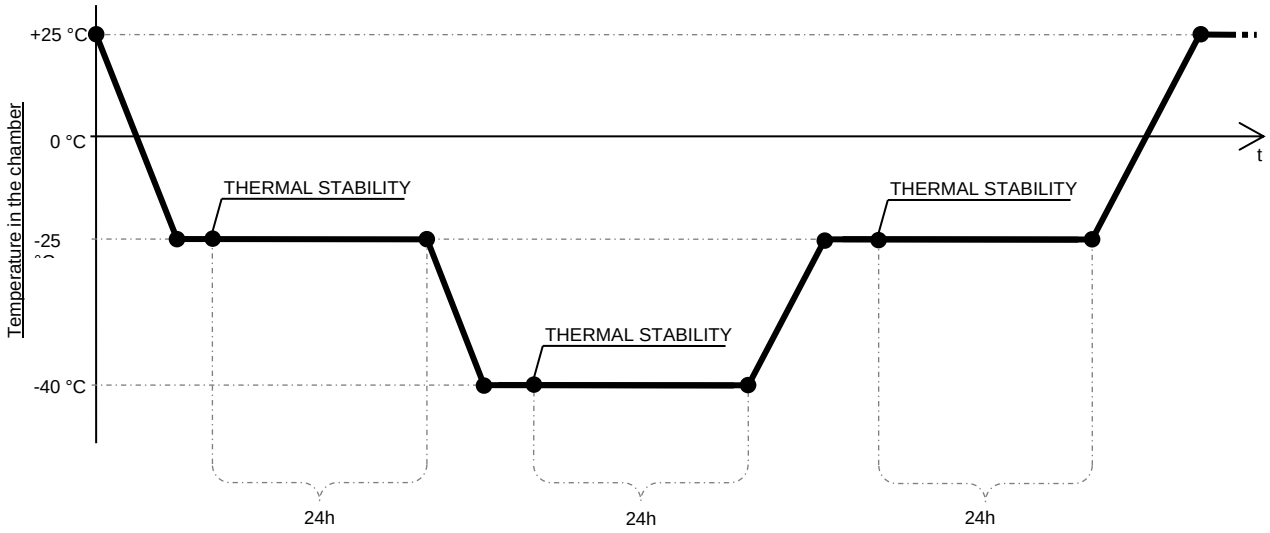
Influence quantity	Value of current for direct connected or transformer operated meters	Power factor	Limits of additional percentage error for meters of class index		
Temperature variation			**A**	**B**	**C**
5 °C to 30 °C	$I_{min} \le I \le I_{max}$	1	± 1,8	± 0,9	± 0,5
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 2,7	± 1,3	± 0,9
-10 °C to 5 °C 30 °C to 40 °C	$I_{min} \le I \le I_{max}$	1	± 3,3	± 1,6	± 1,0
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 4,9	± 2,3	± 1,6
-25 °C to -10 °C 40 °C to 55 °C	$I_{min} \le I \le I_{max}$	1	± 4,8	± 2,4	± 1,4
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 7,2	± 3,4	± 2,4
-40 °C to -25 °C 55 °C to 70 °C	$I_{min} \le I \le I_{max}$	1	± 6,3	± 3,1	± 1,9
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 9,4	± 4,4	± 3,1
Voltage variation ± 10%	$I_{min} \le I \le I_{max}$	1	± 1,0	± 0,7	± 0,2
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 1,5	± 1,0	± 0,4
Frequency variation ± 2%	$I_{min} \le I \le I_{max}$	1	± 0,8	± 0,5	± 0,2
	$I_{tr} \le I \le I_{max}$	0,5 ind, 0,8 cap	± 1,0	± 0,7	± 0,2
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.					

Table 9: Limits of additional percentage error due to influence quantities (single-phase meters and polyphase meters with balanced loads). CEI EN 50470-3.

8.4.6.2 REACTIVE ENERGY (meters of class 2)

- 0.1% (per °C) at power factor = 1 (see CEI EN 62053-23 – Tab.8);
- 0.15% (per °C) at power factor = 0.5 (see CEI EN 62053-23 – Tab.8).

At the end of this period, the chamber's conditions shall be restored to the test values for the specified operating ranges and maintained for 24 hours. The EUT has to restore itself to normal operation without any manual intervention. During this period, the EUT's operations and the functional characteristics, as defined in sub-clause 8.2 shall be verified. As well as for the previous step, checks shall start after the stability of the EUT with the ambient test conditions of the



chamber.

At the end of the exposure time, the ambient conditions inside the chamber shall be restored to the standard atmospheric conditions. Under these conditions, the CE shall be subjected to the functional test defined in sub-clause 8.2.

8.4.7 Change of temperature test

This test, not included in CEI EN 50470-1, shall be carried out in accordance with the conditions and the acceptance criteria of this specification. The test conditions presented in the following table shall be applied.

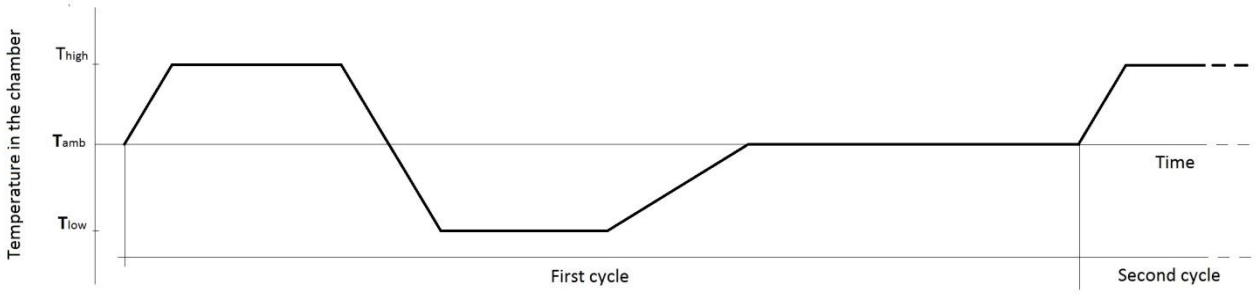
Reference standard : CEI EN 60068-2-14 (test Nb)	
Temperature (°C)	**Duration** (Cycles)
High temperature: +70 (1) Low temperature: -25 (1)	5
Note 1: The tolerance is ±3 °C	

The ambient conditions inside the test chamber shall be raised, from the laboratory ambient temperature (+25°C ± 5°C), to the required high temperature value at a rate of change not lower than 1°C/min (averaged over a period of no more than 5 min.). Such conditions shall be maintained for 3 hours; the exposure start corresponds with the instant when the test chamber temperature has reached the prescribed value.

After this period, the test chamber shall be lowered to the prescribed low temperature with the maximum allowable temperature change rate and maintained for 3 hours. The rate of change (averaged over a period of no more than 5 min) shall not be lower than 1°C/min.

At the end of the low temperature exposure time, the test chamber ambient conditions shall be restored to the standard atmospheric conditions, in this case the temperature rate of change shall not be higher than 0.4 °C/min. After the atmospheric conditions has been reached, they shall be maintained until 6 hours from the start of the temperature increase.

These 3 steps constitutes one cycle.



The EUT shall be maintained in the powered on condition for the whole test duration.

During the whole exposure the functional verifications defined in sub-clause 8.4.2 shall be repeated, especially in the condition of the maximum rate of change, which occurs during the transition from the high to the low temperature.

During the test the humidity is not controlled. The condensation of humidity on the EUT surface is allowed, but is preferable to avoid it. For this reason the test starts from the highest temperature and, at the end, the temperature is restore to the ambient one so slowly.

8.4.8 Solar radiation test

This test is required – by the CEI EN 50470-1 – only for those meters designed for outdoor use. Nonetheless it is required to perform it also on the meters designed for internal use each time serigraphy or plastic are changed.

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

- meter in non-operating condition;
- test procedure A (8 h irradiation and 16 h darkness);
- upper temperature: +55 °C;
- duration of the test: 3 cycles or 3 days.

After the test the meter shall be visually inspected. The appearance and, in particular, the legibility of markings shall not be altered. The function of the meter shall not be impaired.

8.5 TESTS OF ELECTRICAL REQUIREMENTS

8.5.1 Test of power consumption

The power consumption due to additional functionality not covered by CEI EN 50470-1 (DLC communication, relay voltage drop) shall conform the meter functional specifications.

For the purpose of the test, please refer to:

- CEI EN 50470-3, sub-paragraph 7.1.2

Meters (single – and polyphase)	**Power supply connected to the voltage circuits**
Power consumption in voltage circuit	2 W and 10 VA
Power consumption of auxiliary power supply	--

Note: the design of the EUT makes impossible to energize voltage circuits and the current circuits separately.

Note: voltage drop test, required for the test of power consumption, will be done at IMAX.

8.5.2 Test of influence of short time overcurrents

The test shall be performed has described in CEI EN 50470-3 (par. 8.7.8)

Functional characteristics shall be verified before the test. As well as the metrology, for both active and reactive energy.

The test shall be carried out with the EUT in non-operating condition.

The meter for direct connection shall be able to carry a short-time overcurrent of $30*I_{Max}$ with a relative tolerance of +0 % to -10 % for one half-cycle at rated frequency (10 [ms]):

I_{Max} = y [A] → I_{Test} = 30y [KA].

The meter for connection through current transformer shall be able to carry a short-time overcurrent of $20*I_{Max}$ with a relative tolerance of +0 % to -10 % for 0.5 [s]:

I_{Max} = y [A] → I_{Test} = 20y [KA];

For testing the poly-phase meters, differently from the standard, it is required to use a single-phase

source, providing that all the three phases are directly connected in series as this test is considered more severe than the standard one.

After the application of the short time overcurrent, the meter shall be allowed to return to the initial temperature with the voltage circuit(s) energized (about 1 h) then an accuracy test shall be performed. It shall be verified that the following requirements are met:

Meters for	Value of current (balanced)		Power factor	Critical change values for meters of class index		
				A	B	C
Direct connection	I_{ref}	-	1	± 1.5%	± 1.5%	± 1.5%
Connection through current transformer	-	I_n	1	± 1.5%	± 1.5%	± 1.5%
$I_{ref} = 10\ I_{tr}$ $I_n = 20\ I_{tr}$						

Table 10. Effect of short time overcurrents – Critical change value. CEI EN 50470-3 (Par. 8.6)

8.5.3 Test of influence of self-heating

The test shall be carried out as described in CEI EN 50470-3 (par. 8.7.7.5).

After the voltage circuits have been energized at reference voltage for at least 2 h without any current in the current circuits, the maximum current shall be applied to the current circuits:

The percentage error of the meter shall be measured immediately after the current is applied and then at intervals short enough to allow a correct drawing to be made of the curve of error variation as a function of time. The test shall be carried out for at least 1 h, and in any event until the variation of error during 20 min does not exceed 10 % of limits of percentage error at reference conditions:

Value of current for direct connected or transformer operated meters	Power factor	Percentage error limits for meters of class index		
		A	B	C
$I_{min} \le I < I_{tr}$	1	± 2.5	± 1.5	± 1.0
$I_{tr} \le I < I_{Max}$	0.5 ind ... 1 ... cap 0.8	± 2.0	± 1.0	± 0.5
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.				

Table 11. Percentage error limits at reference conditions – Single-Phase Meter. Extrapolated from CEI EN 50470-3 (Table 4)

Value of current for direct connected or transformer operated meters	Power factor	Percentage error limits for meters of class index		
		A	B	C
$I_{tr} \leq I < I_{Max}$	0.5 ind ... 1	± 3.0	± 2.0	± 1.0
NOTE: For the relationships I_{min}/I_{tr} and I_{max}/I_{tr} see CEI EN 50470-1, Table 3.				

Table 12: Percentage error limits at reference conditions – Poly-Phase meters carrying a single-phase load. Extrapolated from CEI EN 50470-3 (Table 5)

With minimum interruptions for changing the measurement point, the percentage error of the meter shall be measured at Power Factor = 1 and Power Factor = 0,5 inductive.

The cable to be used for energizing the meter shall have a length of 1 m and a cross-section to ensure that the current density is between 3,2 A/mm^2 and 4 A/mm^2.

It is required that the terminal of the cable that is inserted in the connector shall be made in copper.

It shall be verified that the variation in percentage error does not exceed the critical change value specified below:

8.5.3.1 ACTIVE ENERGY

Disturbance	Value of current	Power factor	Critical change values for meters of class index		
			A	B	C
Self-Heating	I_{Max}	1	± 1.0%	± 0.7%	± 0.2%
		0.5 ind	± 1.5%	± 1.0 %	± 0.2%

Table 13. Effect of Self-Heating (disturbance of long duration) – Critical change values. Extrapolated from CEI EN 50470-3 (Table 9)

8.5.3.2 REACTIVE ENERGY

This test is required even if it is not present in CEI EN 50470-1:

Disturbance	Value of current	Power factor	Critical change values for meters of class index	
			2	3
Self-Heating	I_{Max}	1	± 1.0%	± 1.5%
		0.5 ind	± 1.5%	± 2.0%

Table 14. Effect of Self-Heating (disturbance of long duration) – Critical change values. Extrapolated from CEI EN 62053-23 (Table 4)

8.5.4 Insulation tests

The purpose of these tests is to verify that the meter maintains adequate dielectric qualities under normal conditions of use, considering the effects of the climatic environment and different voltages to which it is subjected under normal conditions of use.

This test shall be done:

- before Damp Heat Test (see §8.4.5) using the 100% of the indicated values;
- after Damp Heat Test (see §8.4.5) using the 80% of the indicated values.

The requirements reported in the following include further details and integration to those defined in CEI EN 50470-1.

8.5.4.1 Test procedures and acceptance criteria

The meter shall be fitted as normally operating, not powered on and without external connections, excluded those ones necessary for carrying out the test. During the impulse and the a.c. voltage tests, the circuits not under test shall be connected to the earth.
For the purpose of these tests, the term "earth" refers to a conductive foil wrapped around the meter touching all accessible conductive parts and connected to the flat conducting surface on which the meter base is placed.

It is not allowed to remove or disconnect modules or devices.

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

The AC voltage test (see §8.5.4.2) shall be applied only in:

- Common Mode → between the terminals of the circuit connected together and the earth.

The impulse voltage test (see §8.5.4.3) shall be carried out both in:

- Common Mode → between the terminals of the circuit connected together and the earth;
- Differential Mode → between the terminals of a single circuit and the earth – the applied voltage value shall be half of the one used in common mode.

The a.c. voltage test (see §8.5.4.2) and the impulse voltage test (see §8.5.4.3) shall be preceded and followed by the measurement of the insulation resistance (see §8.5.4.4) in order to detect possible degradation of the insulation performances.

Insulation tests have to start and end with a check, by means of an oscilloscope, of the DLC signal level. During the PLC communication the level shall be greater than 1.3 V_{RMS}.

The results of the insulation tests will be considered satisfactory if:

- the application of the test voltage does not lead to degradations of the insulation performances (no internal or external breakdown or flashover occur);
- the measured value of the insulation resistance is above or equal to the prescribed one (see §8.5.4.4);
- at the end of the tests, the EUT maintains the prescribed operating performances.

If, for any reason, the insulation tests have to be repeated, then they may be performed on a new sample.

8.5.4.2 AC voltage test

The test voltage shall be applied to the EUT in common mode, with a value of 4 kV_{RMS} (see CEI EN 50470-3 at §7.2).

The test voltage shall be substantially sinusoidal, having a frequency between 45 Hz and 65 Hz, and applied for 1 min. The power source shall be capable of supplying at least 500 VA.

For the verifications during the test a suitable oscilloscope is required to display the applied voltage waveform and detect possible flashover.

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

The evaluation of the test result will be done according to the criteria reported in sub-clause 8.5.4.1.

8.5.4.3 Impulse voltage test

The impulse voltage shall be applied to each independent circuit of the meter with a value of 10 kVp, in

common mode.

Note: CEI EN 50470-1 requires a value of 6 kVp for this kind of EUT, but for areas where overhead supply networks are predominant, higher value than the given one is allowed (the value required is 10 kVp).

As aforesaid – in §8.5.4.1 – this test shall be carried out also in differential mode with a voltage value half of the one applied for common mode → 5kVp.

Both in common and differential mode, the test shall be carried out under the following condition:

- Impulse waveform:1,2/50 impulse as specified in HD 588.1 S1;
- Voltage rise time: ± 30%;
- Voltage fall time: ± 20%;
- Source impedance: 500 Ω ± 50 Ω;
- Source energy: 0.5J ± 0.05J;
- Test voltage: in accordance with the mode under test;
- Test voltage tolerance: + 0% to - 10%.

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

For the verifications during the test a suitable oscilloscope is required to display the applied voltage waveform and to detect possible flashover.

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

The evaluation of the test result will be done according to the criteria reported in sub-clause 8.5.4.1.

8.5.4.4 Measurements of the insulation resistance

This test, not included in CEI EN 50470-1, prescribes the insulation resistance measurement between the power port and the earth of the EUT.

The insulation resistance, to be measured with a $500V_{DC}$ test voltage, shall be greater than 1 GΩ.

As aforesaid, the measurement of the insulation resistance shall precede and follow a.c. and impulse voltage tests.

8.6 TESTS FOR ELECTROMAGNETIC COMPATIBILITY (EMC)

8.6.1 Immunity tests

8.6.1.1 Test procedure and acceptance criteria

The immunity requirements to electromagnetic disturbances shall be verified applying the disturbances to all the interfaces with the external electromagnetic environment; these points are identified as “ports”.

Enclosure port: the physical boundary of the equipment through which electromagnetic fields may radiate or impinge: Meter case.

Power ports: the power ports are the power circuits used to energise and passing through the enclosure port of the equipment to be tested: meter power line (phases R, S, T and neutral);

Signal ports: the signal ports are the input/output circuits used for the communication and control from/to the equipment to be tested: meter power line (R, S, T phases and neutral).

The signal port of the meter corresponds with the power port.

The infrared interface is considered as not relevant for the application of conducted disturbances.

During the immunity tests, the meter shall be maintained in the following operating conditions:

- reference voltage U_n ;
- basic current I_b or nominal current I_n ;
- power factor unity:
  - $cos\varphi = 1$ → active power;
  - $sin\varphi = 1$ → reactive power.

For all these tests the meter shall be in its normal working position with the terminal cover in place.

Electromagnetic disturbances of long duration shall not cause an additional percentage error more than the critical change values specified in the relevant particular requirements standard.

The effect of transient electromagnetic disturbances shall be such that:

- during and immediately after a disturbance, the test output device shall not generate a signal equivalent or greater to ***x***;

and in a reasonable time after the disturb, the meter shall:

- recover to operate within the error limits specified in the relevant standards;
- keep all measurement functions safeguarded;
- allow the recovery of all data computed/stored prior the disturb;
- not indicate changes in the registers greater than ***x***;

where ***x*** (critical change value in kWh units) is the critical change value computed as follow:

$$x = 10^{-6} \cdot m \cdot U_n \cdot I_{max}$$

where:

m is the number of measuring element;

U_n is the reference voltage in Volts;

I_{max} is the maximum current in Amperes.

The test set-up shall include the suitable auxiliary equipment to check all the functions described hereafter. These equipment will be arranged in accordance with the relevant basic standard for immunity.

The assessment criteria is based on the nature of the electromagnetic phenomena (type and occurrence) and on the representative functions of the equipment concerned. The requirements are also related with the probability of occurrence of the disturbance (continuous, high occurrence transient and low occurrence transient).

The assessment criteria are showed in the following table; in the description of each test, the nature of the disturbance is indicated.

Functions(*)	**Functional requirements versus nature of electromagnetic phenomena**		
	Continuous	**High occurrence transients**	**Low occurrence transients**
Data storage	**Normal performances within the specification limits**		
Times base clock/calendar			
Metering and counting (quality parameters of the LV network included)			temporary degradation(1)
Communication of the CE via DLC		no loss, possible degradation of the bit error rate(2)	temporary loss(2)
Relay command		short delay(3)	
Communication of CE to HHU via infrared interface and display		temporary degradation	stop and reset(4)
Alarm		short delay(3)	temporary loss(5)
Self-diagnostic		temporary loss, self recovered(6)	

NOTES:
* For multiple or concurrent functions the performance related to the most critical function applies.
(1) A doubling of the accuracy class is allowed.
(2) Temporary bit error rate degradation can affect the communication efficiency; automatic restoration of any stoppage of the communication is mandatory.
(3) A short delay that is insignificant compared to the time constant of the controlled process is acceptable.
(4) Manual restoration by operators is allowed.
(5) Temporary loss with automatic restoration is allowed.
(6) Within the system self-diagnostic cycle.

Table 15. Assessment criteria for the different functions (in descending order of criticality).

8.6.1.2 Immunity to damped oscillatory waves test

The following paragraph describes the test levels and the reference documents of this test, also included in CEI EN 50470-1 (see §7.4.10) and CEI EN 62052-11 (see §7.5.7).

Current test shall be performed on all model of meter, even if it would be required only for transform-operated meters.

The test shall be carried out according to CEI EN 61000-4-12, under the following condition:

- Tested as table-top equipment.
- Meter in operating condition as described before in §8.6.1.1.
- Test voltage:
  - Common Mode: 2.5 kV;

- Differential Mode: 1.0 kV.

- Test frequencies:
  - 100 kHz, repetition rate: 40 Hz;
  - 1 MHz, repetition rate: 400 Hz.
- Test duration: 60 s (15 cycles with 2 s on, 2 s off, for each frequency).

During the test, the behaviour of the meter shall not be disturbed and the additional percentage error shall not exceed the critical change values specified below:

8.6.1.2.1 ACTIVE ENERGY

Disturbance	Value	Power factor	Critical change values for meters of class index		
			A	B	C
Damped oscillatory waves	2.5 kV / 1 kV	1	± 3.0%	± 2.0%	± 1.0%

Table 16. Effect of Damped Oscillatory Waves (disturbance of high occurrence transient) – Critical change values. Extrapolated from CEI EN 50470-3 (Table 9)

8.6.1.2.2 REACTIVE ENERGY

Disturbance	Value	Power factor $sin\varphi$	Critical change values for meters of class index	
			2	3
Damped oscillatory waves	2.5 kV / 1 kV	1	± 4.0%	± 4.0%

Table 17. Effect of Damped Oscillatory Waves (disturbance of high occurrence transient) – Critical change values. Extrapolated from CEI 62053-23 (Table 8)

For the assessment of the result, the disturbance of this test is classified as high occurrence transient.

8.6.1.3 Conducted disturbances, frequency range [0, 150] kHz, immunity test.

The following table describes the test level and the reference document required for this test although it is not included in IEC 50470-1.

Ports	Reference standard	Test level
Power / Signal	IEC 61000-4-16(1)	Level 3(2)
NOTES: (1) The lower frequency limit is 15 Hz. (2) For the profile of the test voltage versus the frequency, see Figure 2.		

Table 18. Conducted disturbances, frequency range [0 , 150] kHz, immunity test

No test level is defined below 15 Hz, as tests in this frequency range are not considered to be relevant.

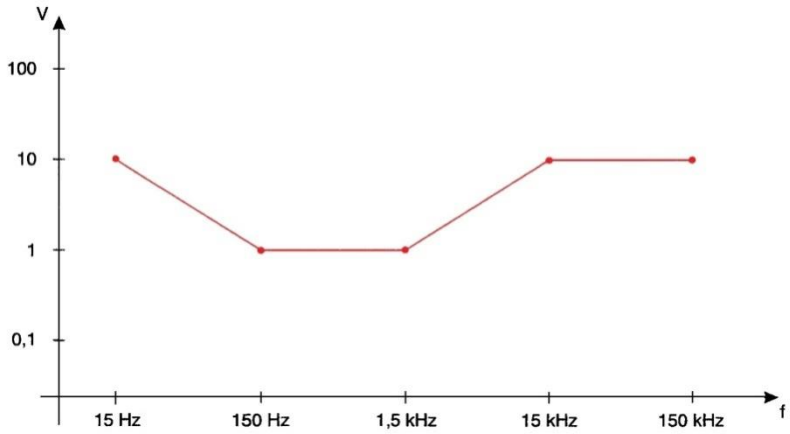


Figure 2. Profile of the test voltage for Test Level 3. CEI EN 61000-4-16.

The test in the frequency range 15 Hz-150 kHz starts from 15 Hz.
The rate of sweep shall not exceed $1x10^{-2}$ decade/s. Where the frequency is swept incrementally, the step size shall not exceed 10% of the start and thereafter 10% of the preceding frequency value.

The meter shall be in operating condition.

In order to minimize the impact of environmental parameters on test results, the tests shall be carried out in climatic and electromagnetic reference conditions. In accordance with IEC 60068-1, the standard climatic conditions are:

- ambient temperature: 15 °C to 35 °C;
- relative humidity: 25% to 75%;
- atmospheric pressure: 86 kPa (860 mbar) to 106 kPa (1060 mbar).
- Duration test: 3600 seconds.

The main steps of the test procedure are as follows:

- Preliminary verification of equipment performances;
- Connection of the coupling networks and decoupling devices to the EUT's ports to be tested;

- Application of the test voltage (in common mode);
- Continuous monitoring of the EUT's communication (it has to be working properly all test long).

For the assessment of the result, the disturbance of this test is classified as continuous.

8.6.1.4 Immunity to conducted disturbance, induced by radio-frequency fields

The reference of this test is in the CEI EN 50470-1 paragraph 7.4.8.

The test shall be carried out according to CEI EN 61000-4-6, under the following conditions:

- tested as table-top equipment;
- meter in operating condition;
- voltage and auxiliary circuits energized with reference voltage;
- current and power factor as specified in the relevant standard;
- frequency range: 150 kHz to 80 MHz;
- Step frequency: 1%
- Disturbance duration: 3 s;
- voltage level: 10 V.

During the test the behaviour of the equipment shall not be perturbed, and the additional percentage error shall not exceed the critical change values specified in Table 19.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Conducted disturbances induced by RF fields	10 V	10 I_{tr}	I_n	1	±3,0	±2,0	±1,0

Table 19. Effect of disturbance of long duration - critical change values in relation to conducted disturbance

The meter shall be in operating condition.

In order to minimize the impact of environmental parameters on test results, the tests shall be carried out in climatic and electromagnetic reference conditions. In accordance with IEC 60068-1, the standard climatic conditions are:

- ambient temperature: 15 °C to 35 °C;
- relative humidity: 25% to 75%;
- atmospheric pressure: 86 kPa (860 mbar) to 106 kPa (1060 mbar).

The main steps of the test procedure are as follows:

- Preliminary verification of equipment performances;
- Connection of the coupling networks and decoupling devices to the EUT's ports to be tested;
- Application of the test voltage (in common mode);
- Continuous monitoring of the EUT's communication (it has to be working properly all test long).

For the assessment of the result, the disturbance of this test is classified as continuous.

8.6.1.5 Surge immunity test

The following paragraph describes the test levels and the reference documents of this test, also included in CEI EN 50470-1.

The test has to be carried out according to EN 61000-4-5, in the following conditions:

- Meter in operating condition:
  - voltage and auxiliary circuits energised with reference voltage, ± 5%;
  - without any current in the current circuits and the current terminals have to be in open circuit;
- Cable length between surge generator and the EUT: 1m;
- Tested in differential mode (between line to line);
- Phase angle: pulses to be applied at 60° and 240° vs to Zero Crossing of A.C. Supply;
- Test voltage on the current and voltage circuits (main lines): 4kV, generator source impedance: 2 Ω;
- Number of pulses: 5 positive and 5 negative;
- Repetition rate: maximum 1/min.

Executing the surge immunity test has not to provoke a change in the register greater than x units and the test output has not to produce a signal equivalent to more than x units (for this value see paragraph 8.6.1.1); also at the beginning and end of this test the meter should be checked in its main features, these are:

- DLC communication;
- Optical communication;
- Display.

During the test, a temporary degradation or loss of function or performance is acceptable.

8.6.1.6 Fast transient/burst immunity test

The following table describes the test levels and the reference documents of this test, also included in CEI EN 50470-1 (see 7.4.7).

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Electrical fast transient/burst	4 kV (common mode) 2 kV (differential mode)	10 I_{tr}	I_n	1	±6,0	±4,0	±2,0

Table 20. Effect of disturbance of long duration - critical change values in relation to electrical fast transient/burst

The test has to be carried out according to EN 61000-4-4, in the following conditions:

- tested as table-top equipment;
- meter in operating condition:
  - voltage and auxiliary circuits energized with reference voltage;
  - current and power factor as specified in the relevant standard;
- cable length between coupling device and EUT: 1 m;
- the test voltage shall be applied in common mode (line to earth) in turn to:
  - the voltage circuits;
  - the current circuits, if separated from the voltage circuits in normal operation;
  - the auxiliary circuits, if separated from the voltage circuits in normal operation;

- test voltage on the current and voltage circuits: 4 kV;
- repetition rate 5 kHz;
- duration of the test: 60 s at each polarity

During the test, a temporary degradation or loss of function or performance is acceptable, nevertheless the additional percentage error shall not exceed the critical change values specified in the relevant standards.
During the test is registered the maximum error using a portable power meter.
Note: Due to the type of set-up for this test, metrology error is calculated as the difference. The first step is measure the intrinsic error of the system and then during the test is recorded the maximum error, at the end is made the difference between the system error and the maximum error registered.

For the assessment of the result, the disturbance of this test is classified as high occurrence transient.

8.6.1.7 Accuracy in presence of harmonics

The test is included in CEI EN 50470-3 (see paragraph 8.7.7.7).
The test shall be performed under the following conditions:

- fundamental frequency current $I_1 = 0{,}5\ I_{MAX}$;
- fundamental frequency voltage $U_1 = U_n$;
- fundamental frequency power factor 1;
- content of 5th harmonic voltage $U_5 = 10\%\ U_n$;
- content of 5th harmonic current $I_5 = 40\%\ I_1$;
- harmonic power factor 1;
- fundamental and harmonic voltages are in phase, at positive zero crossing.

Resulting

- harmonic power due to the 5th harmonic → $P_5 = 0.1U_1 * 0.4I_1 = 0.04P_1$
  or
- total active power $= 1.04P_1$ (fundamental + harmonics).

It shall be verified that additional percentage error does not exceed the critical change value specified in the following table.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Harmonic components in the current and voltage circuit	10% U, 40% I 5th harmonic	0,5 I_{max}	0,5 I_{max}	1	±1,0	±0,8	±0,5

Table 21: Effect of disturbance of long duration – critical change values in relation harmonic components in the current and voltage circuit

8.6.1.8 Influence of d.c. and even harmonics in the a.c. current circuit

The references of this test is in CEI EN 50470-3 (see paragraph 8.7.7.8).
The tests of the influence of direct current and even harmonics shall be made with the circuit shown in Figure 3, or with other equipment able to generate the required waveforms, and the current waveforms as shown in Figure 4.

- The distortion factor of the voltage shall be less than 1 %.
- The value of the current (before applying the distortion) shall be $\frac{I_{max}}{\sqrt{2}}$, at unity power factor.

The additional percentage error when the meter is subjected to the test waveform compared to the percentage error when it is subjected to the reference waveform shall not exceed the critical change value given in Table 22.

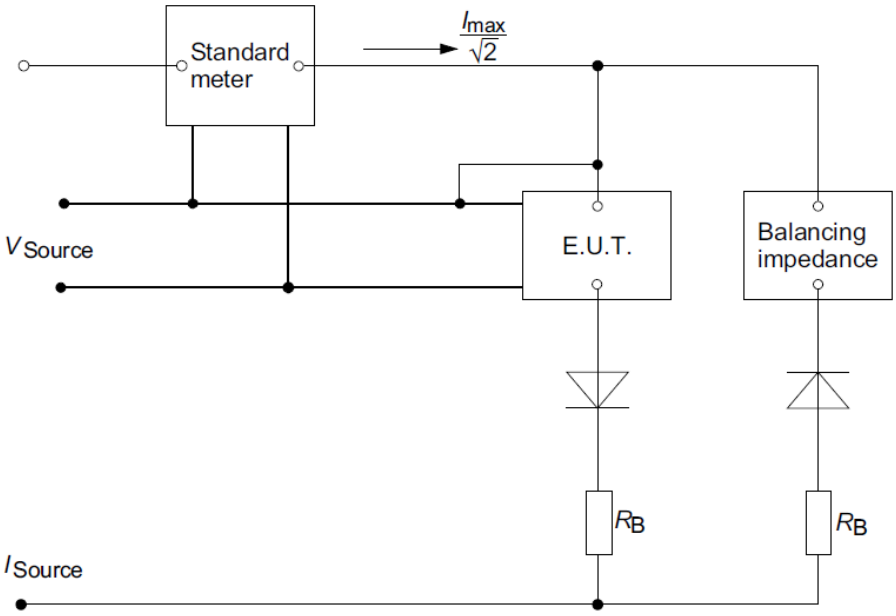


Figure 3: Test circuit diagram for half-wave rectification

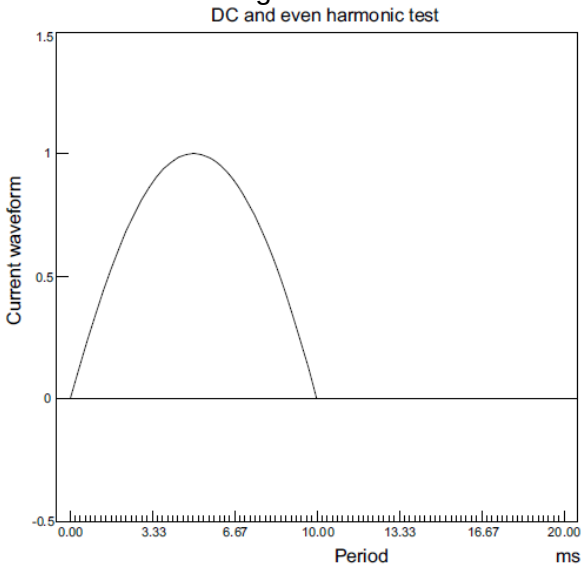


Figure 4: Half-wave rectified waveform

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
DC and even harmonics in the a.c. current circuit		$\frac{I_{max}}{\sqrt{2}}$	-	1	±6,0	±3,0	±1,5

Table 22. Effect of disturbance of long duration - critical change values in relation DC and even harmonics in the a.c. current circuit

8.6.1.9 Odd harmonics and sub-harmonics in the a.c. current circuit

The reference of this test is in CEI EN 50470-3 (see paragraph 8.7.7.9).
The tests of the influence of odd harmonics and sub-harmonics shall be made with the circuit shown in Figure 5 or with other equipment able to generate the required waveforms, and the current waveforms as shown in Figure 6 and Figure 7 respectively.
The distortion factor of the voltage shall be less than 1%.
The additional percentage error when the meter is subjected to the test waveform compared to the percentage error when it is subjected to the reference waveform shall not exceed the critical change value given in Table 23.

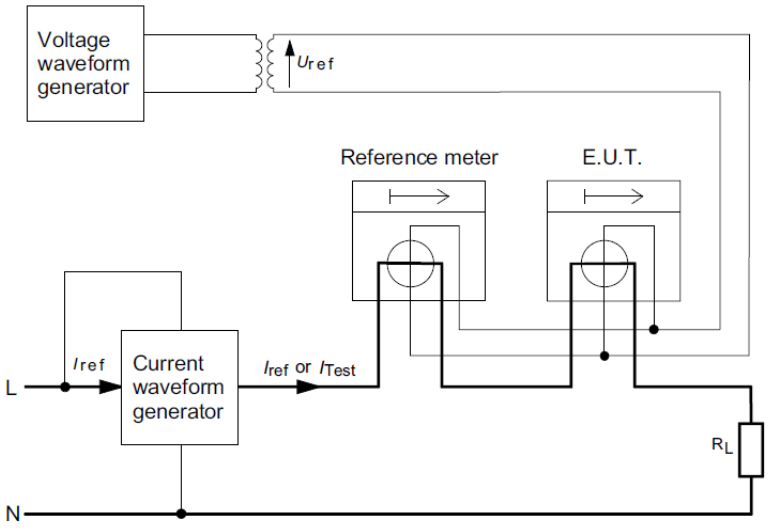


Figure 5: Test circuit diagram (informative)

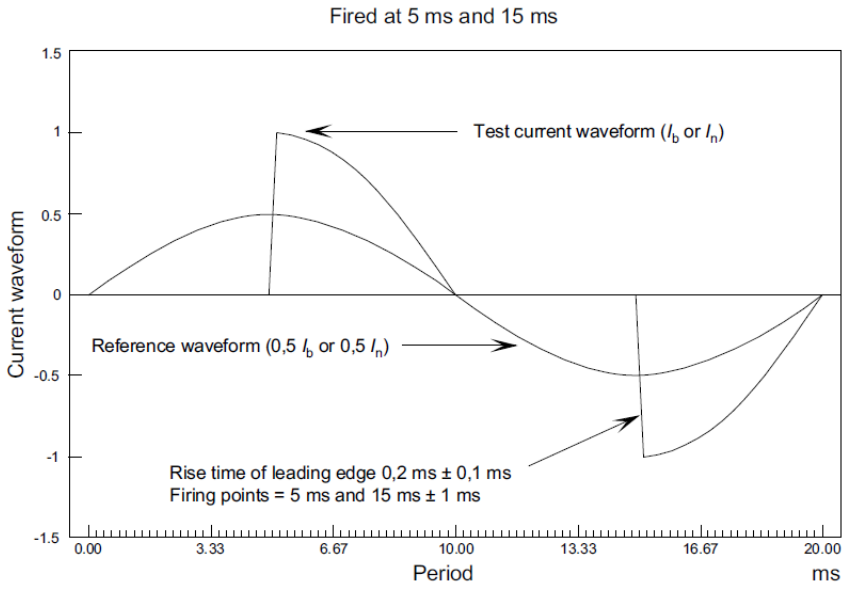


Figure 6: Phase fired waveform

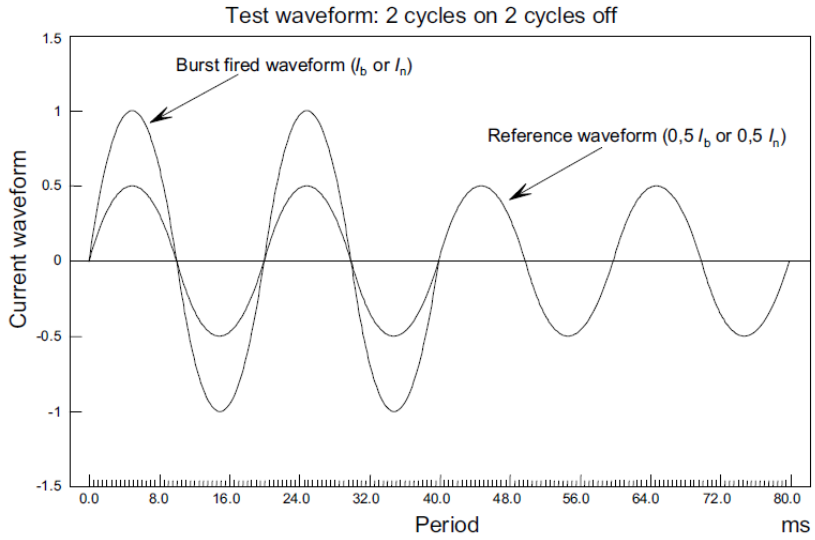


Figure 7: Burst fired waveform

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Odd harmonics in the a.c. current circuit		5 I_{tr}	0,5 I_n	1	±6,0	±3,0	±1,5
Sub-harmonics in the a.c. current circuit		5 I_{tr}	0,5 I_n	1	±6,0	±3,0	±1,5

Table 23: Effect of disturbance of long duration - critical change values in relation to odd harmonics and sub-harmonics in the a.c. current circuit

8.6.1.10 Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

The following table describes the test level and the reference document for this test, not included in CEI EN 50470-1. The purpose is to verify the immunity of the EUT to the disturbances produced by harmonics, inter-harmonic voltages and signals transmitted in the network.

Ports	Reference standard	Test level
Power	CEI EN 61000-4-13 + A1	3

For the assessment of the result, the disturbance of this test is classified as continuous.

8.6.1.11 Voltage dips, short interruptions and voltage variation immunity test

The following paragraph describes the test levels and the reference documents of this test, also included in CEI EN 50470-1 paragraph 7.4.4.
The tests shall be carried out according to CEI EN 61000-4-11, under the following conditions:

- voltage and auxiliary circuits energized with reference voltage ± 5 %;
- without any current in the current circuits.

TESTS

a) voltage interruptions of ΔU = 100 %
   - interruption time: 1 s;
   - number of interruptions: 3;
   - restoring time between interruptions: 50 ms.

See also Figure **8** below.

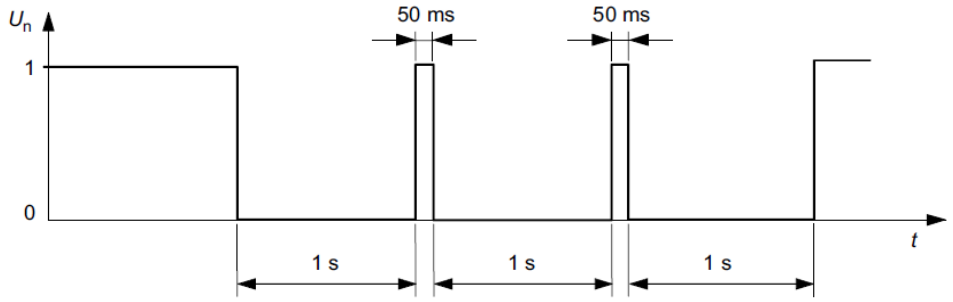


Figure 8: Voltage interruptions of ΔU = 100%, 1 s

b) voltage interruptions of ΔU = 100 %
   - interruption time: one cycle at reference frequency;
   - number of interruptions: 1.

See also Figure 9 below.

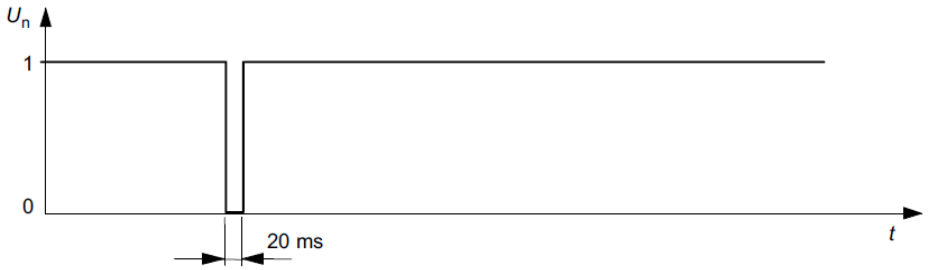


Figure 9: Voltage interruptions of ΔU = 100 %, one cycle at rated frequency

c) voltage dips of ΔU = 50 %
   - dip time: 1 min;
   - number of dips: 1.

See also Figure 10 below.

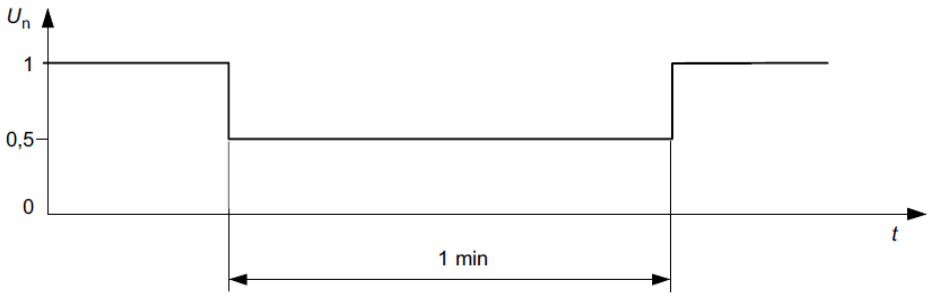


Figure 10. Voltage Dips of ΔU = 50 %.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Severe voltage variation	$0,8U_n \leqslant U < 0,9U_n$ $1,10U_n \leqslant U < 1,15U_n$	10 I_{tr}	I_n	1	±3,0	±2,1	±0,6
	$U < 0,8U_n$			0,5 ind	±4,5	±3,0	±1,2
				1 and 0,5 ind	+ 10...-100		

Table 24. Effect of disturbance of long duration – critical change values in relation to severe voltage variation.

For the assessment of the result, the disturbance of this test is classified as follows:

- slow voltage variation: continuous;
- voltage dips with duration ≤ 20 ms: high occurrence transients;
- voltage dips with duration > 20ms and interruptions: low occurrence transients.

The above mentioned test levels do not exclude the possibility to verify the immunity with different values. In addition to the criteria described in sub-clause 8.6.1.1 it is required that the EUT, after power-off and power-on, shall restore automatically the operating conditions.

8.6.1.12 Electrostatic discharges immunity test

This test is included in CEI EN 50470-1 (see paragraph 7.4.5).
The test shall be carried out in according to CEI EN 61000-4-2, under the following condition:

- tested as table-top equipment;
- meter in operating condition:
  - voltage and auxiliary circuits energized with reference voltage ± 5 %;
  - without any current in the current circuits (open circuit);
- contact discharge:
  - test voltage: 8 kV;
  - number of discharges: 10 (in the most sensitive polarity).

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

Note: for meters of Protective Class II air discharge is most likely to be applicable.

The application of all the electrostatic discharges shall not produce a change in the register of more than x units and the test output shall not produce a signal equivalent to more than x (see paragraph 8.6.1.1)

For the assessment of the result, the disturbance of this test is classified as high occurrence transient.

8.6.1.13 Power frequency magnetic field immunity test

This test is included in CEI EN 50470-1 (see 7.4.12).

The test shall be carried out according to EN 61000-4-8, under the following conditions:

- tested as table-top equipment;
- induction coil as per Subclause 6.2.1.a) of EN 61000-4-8;
- immersion method;
- the current flowing through the coil shall be applied in the most unfavourable conditions of phase and direction compared to the voltage(s) energising the meter;
- frequency equal to reference frequency;
- magnetic field applied in three perpendicular planes;
- meter in operating condition:
    - voltage and auxiliary circuits energised with reference voltage;
    - current and power factor as specified in the relevant standard;
- test with continuous field, field strength 0,5 mT.

During the test the behaviour of the equipment shall not be perturbed and the additional percentage error shall not exceed the critical change values specified in Table 25.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Power frequency magnetic fields of external origin	0,5 mT	10 I_{tr}	I_n	1	±3,0	±2,0	±1,0

Table 25: Effect of disturbance of long duration – critical change values in relation to power frequency magnetic fields of external origin

For the assessment of the result, the disturbance of this test is classified as continuous.
During the test the following functionality are tested:

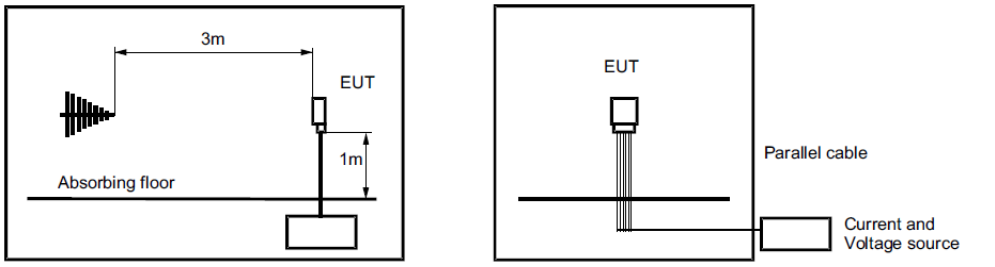
- DLC Communication;
- Optical Communication;
- Status word (are not permitted variation of these field);
- Latching relay has not to be influenced.

8.6.1.14 Radiated, radio-frequency electromagnetic field immunity test

This test is included in CEI EN 50470-1 (see 7.4.6).
The test shall be carried out according to CEI EN 61000-4-3, under the following conditions:

- tested as table-top equipment;
- cable length, exposed to the field: 1 m;
- frequency band: [80 , 2 000] MHz;
- carrier modulated with 80 % AM at 1 kHz sine wave.

For example of test set-up see Figure 11.



NOTE To obtain the test field strength of 30 V/m it is possible to reduce the distance between antenna and EUT down to 1,5 m. In this case, the adjustment of the amplifier must be controlled by a field sensor.

Figure 11 : Test set-up for immunity to radiated RF electromagnetic fields.

TESTS

a) Test with current:
- meter in operating condition:
- voltage and auxiliary circuits energized with reference voltage;
- current and power factor as specified in the relevant standard;
- unmodulated test field strength: 10 V/m. It is possible to carry out the test with values higher than the minimum ones required by the standard (30 V/m is the required value);
- During the test, the behaviour of the equipment shall not be perturbed, and the additional percentage error shall not exceed the critical change values specified in Table 26.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index, %		
		For direct connected meters	For transformer operated meters		A	B	C
Radiated RF electromagnetic fields	Required 30 V/m	10 I_{tr}	I_n	1	±3,0	±2,0	±1,0

Table 26. Effect of disturbance of long duration – critical change values in relation to radiated RF electromagnetic fields

b) Test without any current:
- meter in operating condition:
- voltage and auxiliary circuits energized with reference voltage ± 5 %;
- without any current in the current circuits and the current terminals shall be open circuit;
- unmodulated test field strength: 30 V/m.

The application of the RF field shall not produce a change in the register of more than x units and the test output shall not produce a signal equivalent to more than x units (see 8.6.1.1). During the test, a temporary degradation or loss of function or performance is acceptable.
For the assessment of the result, the disturbance of this test is classified as continuous.

During the test the following functionality are tested:
- DLC Communication;
- Status word (are not permitted variation of these field);
- Latching relay has not to be influenced.

Note: The meter is tested on each side (front – rear – left – right)
Note: If the meter has many types of communication DLC subsequent immunity tests with other modulations DLC will be performed only on the right side and the front.

8.6.1.15 Pulse magnetic field immunity test

This test is not included in CEI EN 50470-1/3, but it is required.

The following tests are intended to demonstrate the immunity of equipment when subjected to impulse magnetic fields related to the specific location and installation condition of the equipment (e.g. proximity of equipment to the disturbance source).

The scope of this test is verify that Meter is immune at this kind of impulse, in the table is presented the value of the test.

Level	Pulse magnetic field strength (A/m)
5	1000

Table 27: Test level

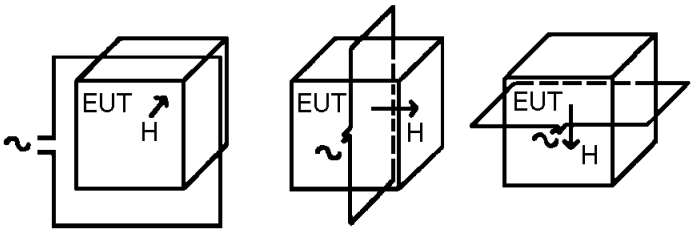


Figure 12: Example of application of the test field by the immersion method

During the test, a temporary degradation or loss of function or performance is acceptable.

Before and after the test the functionalities listed under must be tested:

- DLC Communication;
- ZVEI Communication;
- Status word (are not permitted variation of the normal condition of these field after test, in particular the bit related to *'magnetic field'*);
- Latching relay has not to be influenced.

8.6.1.16 Severity level, immunity requirements for conducted disturbances in the frequency range 2 kHz – 150 kHz

This test is related to immunity levels against symmetric currents in the frequency range from 2 kHz to 150 kHz as an extension of the harmonised standard CEI EN 50470-1/3. This test is not yet a part of actual basic standards or product standard in EMC, but it is required compliance of the products using as a guideline the CLC/TR 50579 technical report.
In the

Figure 13 is presented an example for testing circuit for a Poly-Phase meter.

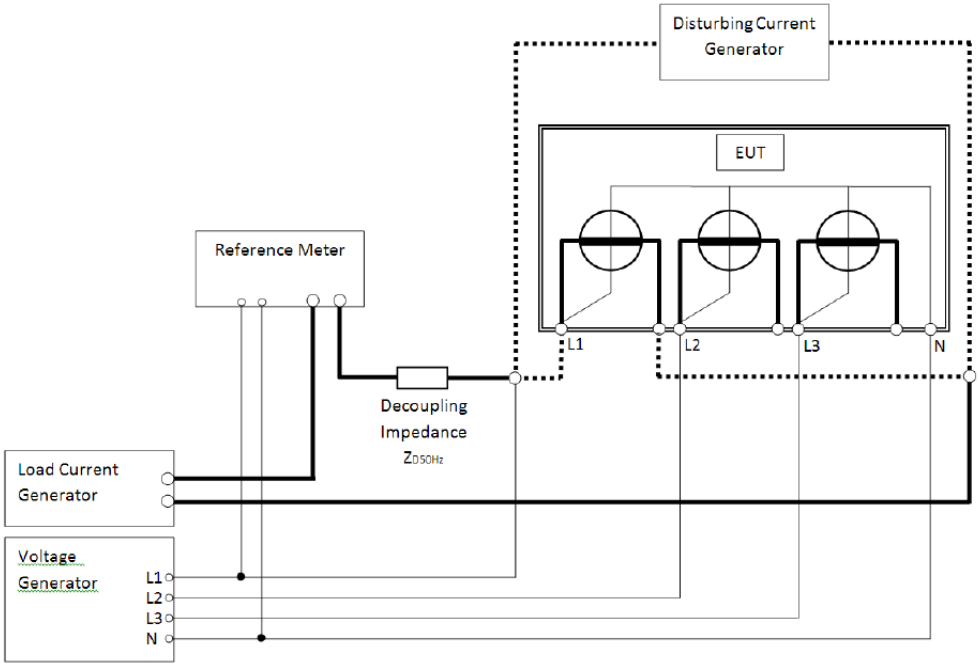


Figure 13: Test circuit

In Table 28 are show the maximum allowed additional percentage error and the level of the test.

Frequency range	**Value of disturbing current**	**50 Hz current**	**50 Hz: cos φ**	**Maximum allowed additional percentage error for electricity meter class**		
				A	B	C
2 kHz to 30 kHz	2A	I_{ref}	>0,9	± 6%	± 4%	± 2%

30 kHz to 150 kHz	1A	I_{ref}	>0,9	± 6%	± 4%	± 2%

Table 28. Maximum allowed additional percentage error depending on accuracy class for direct connected meters

Note: at transition frequency for the frequency range the higher test level applies.

8.6.2 Emission measurements

The levels of conducted and radiated emission shall be measured in the conditions and with the set-up defined in CEI EN 55022 / CISPR 22 the emission shall comply the limits for class B equipment.

For the particularity of devices that use DLC communication for conducted emission in the range 9 to 148,5 shall be used CEI EN 50065-1, this kind of device, in relation of normative, is a device class 134; this mean that the output level measured by the method described in 6.2.2 (CEI EN 60052-1) shall not exceed 134 dB (µV).

It is required that emission measurements are made in two different conditions:

- RX mode: the meter does not use the DLC communication during the test
- TX mode: the meter is programmed to continuously send message. The massage send has a length of 500 ms on a period of 1 second then it has a duty cycle of 50%.

Note: To send in Tx mode the meter it must be used a specific SW with an appropriate scenery (TX mode.scenario)

Note: When the meter is in TX mode the conducted emission test it will be performed, for the first modulation in whole range, for subsequent modulation only in the range 9 kHz - 1 MHz.

8.6.2.1 Limits for conducted disturbance at mains terminal

The equipment under test (EUT) shall meet the limits in Table 30, including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and quasi-peak detector receiver and measured. In the table are reported the set-up for channel receiver.

Scan Setting					
Start	Stop	Step	IF BW	Detector	M-Time
9 kHz	150 kHz	200 Hz	200 Hz	PK + AV	1s
150 kHz	5 MHz	1 kHz	10 kHz	PK + AV	1s
5 MHz	30 MHz	2 kHz	10 kHz	PK + AV	1s

Table 29: The set-up for channel receiver

8.6.2.1.1 Frequency band 9 kHz to 150 kHz

Conducted disturbances
Decreasing linearly with the logarithm of frequency from 89 to 66 dB (µV) quasi peak. In Figure 14 is shown the voltage limit for spurious outputs in other bands.
For the measurements of the output level as indicated in Figure 14, an artificial network shall be used. The characteristic impedance as to be a function of frequency according to the Figure 16 of EN 550161-2:2004.
In addition to the normative requirements, in the frequency range 70 kHz to 90 kHz the QP conducted emission level while the EUT in receiving mode shall be less than 40 dB(uV) Figure 15.

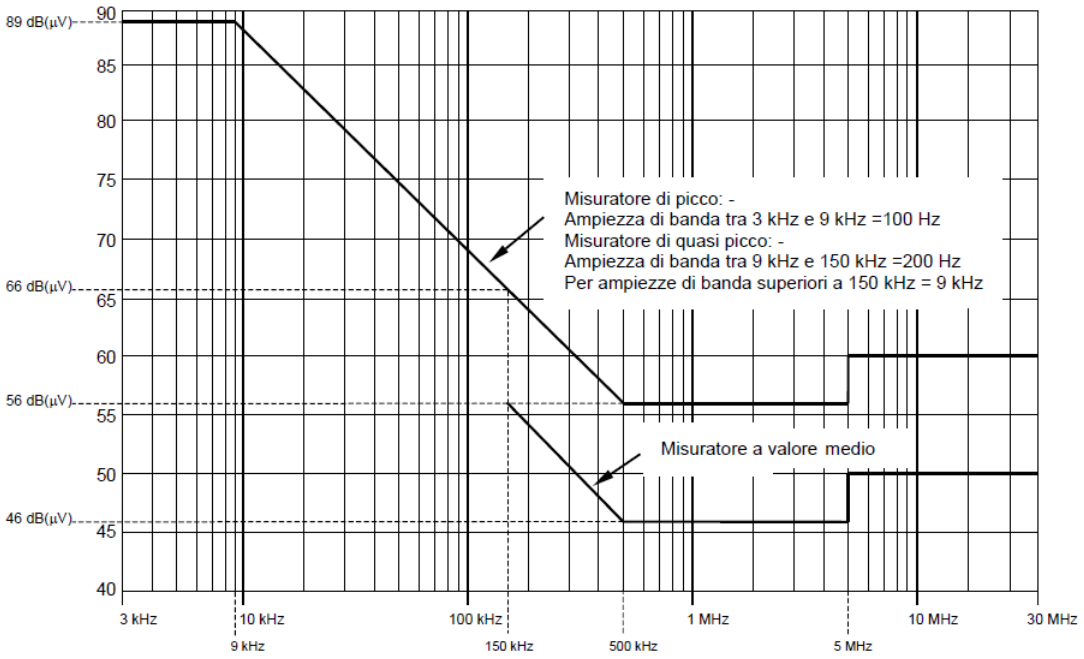


Figure 14: Voltage limits for spurious outputs in other bands CEI EN 50065-1

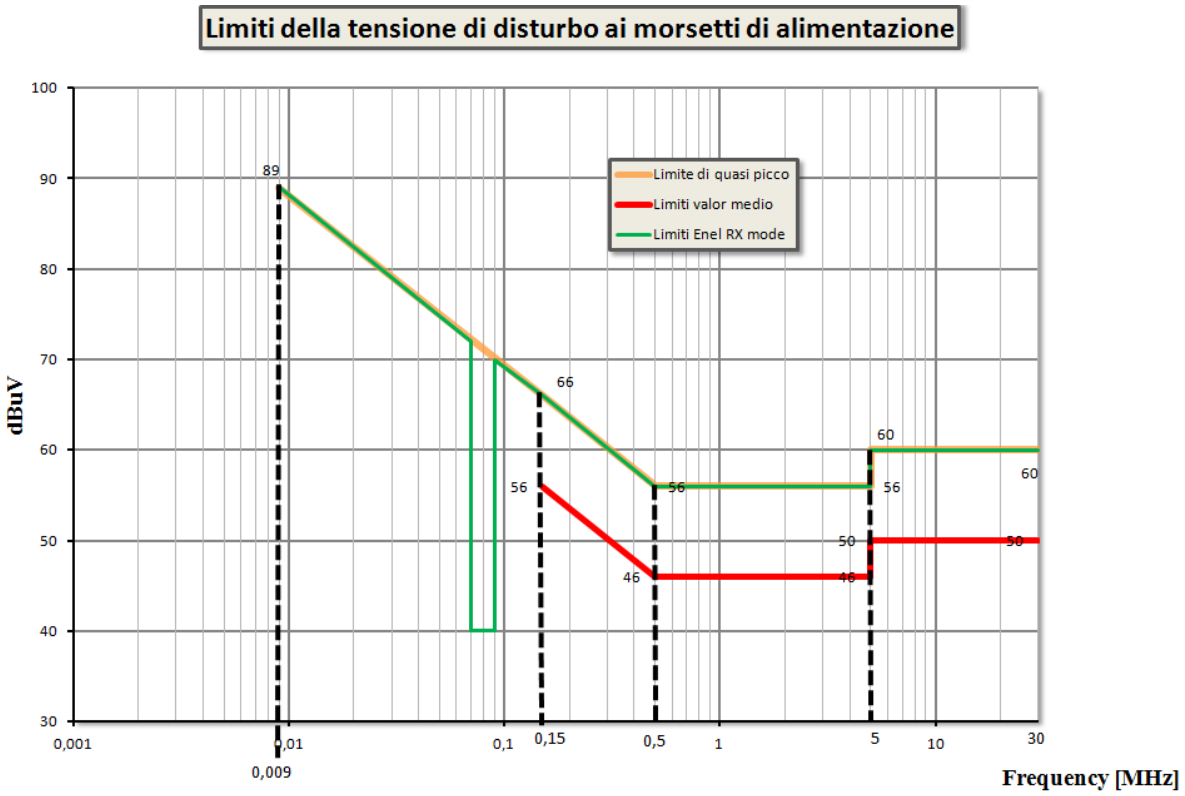
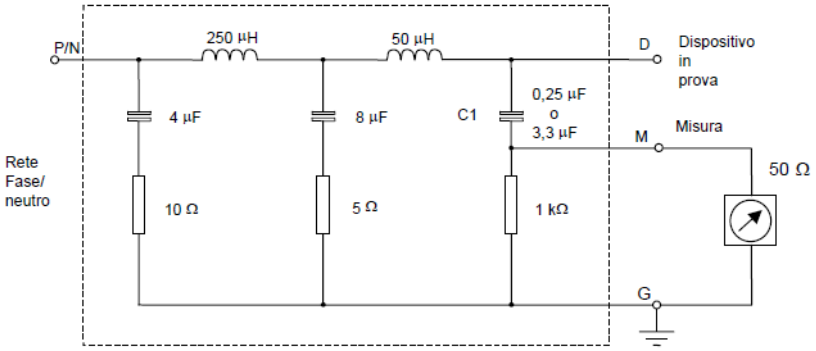


Figure 15: Voltage limits for spurious outputs in other bands and particular requirements



Tipologia di rete come in 4.2, Fig. 4, della EN 55016-1-2:2004
C1 = 3,3 µF da 9 a 95 kHz
C1 = 0,25 µF da 95 a 148,5 kHz

Errore di impedenza < 10%
Errore di misura < 10%
Tensione a 50 Hz nel punto di misura 11,9 V

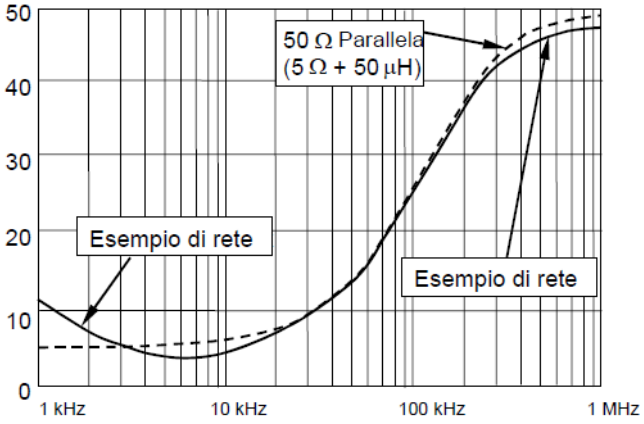


Figure 16: Example of artificial network

8.6.2.1.2 Frequency band 150 kHz to 30 MHz

Continuous disturbances

Limits for mains terminal disturbance voltage in the frequency band 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50µH CISPR network (Figure 16) are given in Table 30.

Class B equipment limits dB(µV)		
Frequency band MHz	Groups 1 and 2	
	Quasi-peak	Average
0,15 – 0,50	66 Decreasing linearly with algorithm of frequency to 56	56 Decreasing linearly with algorithm of frequency to 46
0,50 – 5	56	46
5 - 30	60	50
Note 1: care should be taken to comply with leakage current requirements Note 2: the lower limit shall apply at the transition frequencies Note 3: the limit decreases linearly with algorithm of the frequency in the range 0,15MHz to 0.50MHz		

Table 30: Limits for conducted disturbance at mains ports of class B

8.6.2.1.3 Radio Interference suppression

The test shall be carried out according to CEI EN 55022, under the following conditions:

- For class index B equipment
- Tested as table-top equipment
- For connection to the voltage circuits, an unshielded cable length of 1 m to each connector shall be used
- Meter in operating condition:
  - voltage and auxiliary circuits energised with reference voltage
  - with a current between $0,1*I_{Ref}$ and $0,2*I_{Ref}$ (drawn by linear load and connected by unshielded cable length of 1 m).

The test result shall comply with the requirements given in the following table.

Frequency range MHz	**Quasi-peak limits dB(μV/m)**
30 to 230	30
230 to 1000	37
Note 1 The lower limit shall apply at the transition frequency *Note 2 Additional provisions may be required for cases where interference occurs*	

In addition, it is required to perform the test both in RX and TX mode.
Note: When the meter is in TX mode the conducted emission test it will be performed starting from 30 MHz up to 300 MHz.

8.6.3 Operation of auxiliary devices

This test applies to meters with auxiliary devices enclosed in the meter case. Such devices may not be operating or actuated continuously.
It shall be verified that due to the operation or actuation of such auxiliary devices, the additional percentage error does not exceed the critical change value specified in Table 31.

Disturbance	**Value**	**Value of current (balanced unless otherwise stated)**		**Power factor**	**Critical change value for meters of class index, %**		
		For direct connected meters	**For transformer operated meters**		**A**	**B**	**C**
Operation of auxiliary devices	Most unfavourable condition	I_{min}	I_{min}	1	±1,0	±0,5	±0,1

Table 31: Effect of disturbances of long duration

As regards the meters that integrate RF modem, this test should be performed on this device also, as follows:

- Put in TX mode the 169 MHz modem using ad hoc SW.
- a suitable instrument (PC with sniffer or spectrum analyzer), that allows you to verify that there is constant communication during the metrological test
- Verify the metrological accuracy at the load indicated in Table 31

In the Figure 17 are shown the set up for this test.

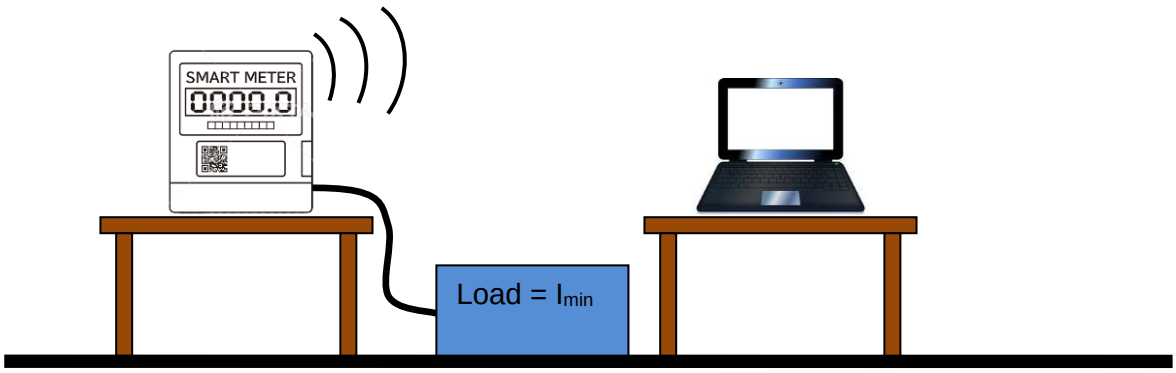


Figure 17: Set up for verify the 169 MHz auxiliary device

8.7 SHORT-CIRCUIT PERFORMANCE

8.7.1 Requirements

The short-circuit performance of output elements shall be determined by the characteristics of the supply fuse so that

- with a prospective short-circuit current of 7 kA r.m.s., cos φ 0,5, it ensures that the surroundings of the tariff and load control equipment are not endangered and that protection against indirect contact is assured in all cases;
- with a prospective short-circuit current of 3 kA r.m.s., cos φ 0,8, the output element still operates under specified conditions.

The characteristics of the supply fuse are to be agreed upon case by case.

Protection against indirect contact must also be assured after the application of a short-circuit from a source with a prospective current of 7 kA r.m.s. through a supply fuse with a rating corresponding to the rated breaking current.

Note The rated breaking current of the output element is often greater than the rated current of the supply fuse which gives the stated short-circuit performance. The user can use the switch contacts in one of two different ways:

- *according to the (higher) rated, breaking current, in which case damage may occur to the contacts as a result of a short circuit, although the probability of such damage is small in practice;*

  or

- *according to the short-circuit performance stated above.*

8.7.2 Test of short-circuit performance

The output elements shall be tested in a test circuit comprising the series connection of the following elements:

- a current source with a prospective short-circuit current of
  - 7 kA r.m.s. with cos φ = 0,5
    or
  - 3 kA r.m.s. with cos φ = 0,8;
- a fuse;
- a switch closing at zero voltage crossover;
- the closed contact of the output switch.

The climatic conditions during the test shall have the reference values given in Table 32.

Stage 1: Test with a fuse corresponding to the rated breaking current. (Fuse to conform to IEC 60269-6-1, with a rated current equal to, or immediately above, the rated breaking current of the switch) Three short-circuit tests shall be carried out with a prospective short-circuit current of 7 kA r.m.s. The test is passed if the protection against indirect contact remains assured. The contacts may weld.

Stage 2: Test with a fuse corresponding to the ability to withstand short-circuits. (Fuse characteristics to be agreed on) Three short-circuit tests shall be carried out with a prospective short-circuit current of 3 kA r.m.s. The test is passed if the output switch can still be operated. This functional check shall be made with one of the programmable sequences with the reference values of Table 32.

Note: if during Stage 1 the contacts do not weld, Stage 2 need not be carried out.

Influencing quantity	**Reference value**		**Limiting values**		
	Value	**Tolerance**	**Maximum value**	**Minimum value**	**Tolerance**
Supply voltage [V]	U_n	±1 %	1,15 U_n	0,80 U_n	± 1 %
Supply frequency [Hz]	f_n	±0,1	1,02 f_n	0,98 f_n	±0,1 %
Temperature [°C]	+23	±3	+55	–25	±2
Relative humidity [%]	65	±10 %	95 %		+0% -5%

Table 32: Reference and limiting values

8.8 TESTS OF ACCURACY REQUIREMENTS

8.8.1 Accuracy test conditions

To test the accuracy requirements, the following test conditions shall be maintained:
the meter shall be tested in its case with the cover in position; all parts intended to be earthed shall be earthed;

A. before any test is made, the circuits shall have been energized for a time sufficient to reach thermal stability;

B. in addition, for Poly-Phase meters:

- the phase sequence shall be as marked on the diagram of connections;
- voltages and currents shall be substantially balanced (see Table 33).

C. the reference conditions are given in Table 34;

D. for requirements regarding test stations, see IEC/TR 60736.

Condition	Tolerance
Each of the voltages between phase and neutral and between any two phases shall not differ from the average corresponding voltage by more than	± 1%
Each of the currents in the conductors shall not differ from the average current by more than	± 2%
The phase displacements of each of these currents from the corresponding phase-to-neutral voltage, irrespective of the phase angle, shall not differ from each other by more than	2°

Table 33. Voltage and current balance

Influence quantity	Reference value	Permissible tolerances for meters of class index		
		A	**B**	**C**
Ambient temperature	Reference temperature or, in its absence, 23 °C (a)	± 2 °C	± 2 °C	± 2 °C
Voltage	Reference voltage	± 1,0 %	± 1,0 %	± 1,0 %
Frequency	Reference frequency	± 0,5 %	± 0,5 %	± 0,5 %
Phase sequence	L1 – L2 – L3	--	--	--
Voltage unbalance	All phases connected			
Wave-form	Sinusoidal voltages and currents	Distortion factor less than:		
		3 %	2 %	2 %
Continuous magnetic field of external origin	Equal to zero	--	--	--
Power frequency magnetic field of external origin	Equal to zero	Induction value which causes a variation of error not greater than (b)		
		± 0,3 %	± 0,2 %	± 0,1 %
Electromagnetic RF field, 30 kHz to 2 GHz	Equal to zero	< 1 V/m	< 1 V/m	< 1 V/m
Operation of auxiliary devices	No operation of auxiliary devices	--	--	--
Conducted disturbances, induced by RF fields, 150 kHz to 80 MHz	Equal to zero	< 1 V	< 1 V	< 1 V

Table 34. Reference condition

Note a: If the tests are made at a temperature other than the reference temperature, including permissible tolerances, the results shall be corrected by applying the appropriate temperature coefficient of the meter determined for the temperature ranges T_{Ref} + 10 °C and T_{Ref} - 10 °C respectively.

Note b: The test consists of:

- *for a single-phase meter, determining the errors first with the meter normally connected to the mains and then after inverting the connections to the current circuits as well as to the voltage circuits. Half of the difference between the two errors is the value of the variation*

of error. Because of the unknown phase of the external field, the test should be made at I_{tr} at unity power factor and at 2 I_{tr} at 0,5 power factor;

- *for a three-phase meter, making three measurements at I_{tr} at unity power factor, after each of which the connection to the current circuits and to the voltage circuits are changed over 120° while the phase sequence is not altered. The greatest difference between each of the errors so determined and their average value is the value of the variation of error.*

8.8.2 Accuracy test at reference conditions

The accuracy test at reference conditions shall be performed at least at the test points shown in Table 35 and it shall be verified that the requirements of 8.1 (see CEI EN 50470- 3) are met. In case of polyphase meters, tests shall be performed with balanced three-phase voltage and with balanced three-phase or single-phase load as indicated. For testing with single-phase load, the test current shall be applied to each measuring element in sequence.

Value of current for meters for		**Meter / Load**		**Power factor**
Direct connection	**Transformer connection**			
I_{min}	I_{min}	1- P	3 - P Balanced	1
I_{tr}	I_{tr}	1- P	3 - P Balanced	0,5 ind,1, 0,8 cap
I_{tr}	I_{tr}	--	3 – P Balanced	1 and 0,5 ind
10 I_{tr}	I_n	1- P	3 - P Balanced	0,5 ind,1, 0,8 cap
10 I_{tr}	I_n	--	3 - P Balanced	1 and 0,5 ind
I_{max}	I_{max}	1- P	3 - P Balanced	0,5 ind,1, 0,8 cap
I_{max}	I_{max}	1- P	3 - P Balanced	1 and 0,5 ind
Note: '1 - P' means single-phase meter. '3 – P balanced' means Poly-Phase meter with balanced load.				

Table 35. Test points determining the intrinsic error and the additional percentage error due to influence quantities

8.8.3 Interpretation of accuracy test results

Certain test results may fall outside the percentage limits indicated in Table 37 and 38, owing to uncertainties involved in the measurement process. However, if by one displacement of the zero line parallel to itself by no more than the limits indicated in Table 36, all the test results are brought within the limits, it shall be considered that the requirements set in those tables are met.

	Meters of class index		
	A	**B**	**C**
Permissible displacement of the zero line (%)	± 1,0	± 0,5	± 0,2

Table 36. Interpretation of test results

Value of current for direct connected or transformer operated meters	**Power factor**	**Percentage error limits for meters of class index**		
		A	**B**	**C**
$I_{min} \leq I < I_{tr}$	1	± 2,5	± 1,5	± 1,0
$I_{tr} \leq I \leq I_{max}$	0,5 ind , 1 , 0,8 cap	± 2,0	± 1,0	± 0,5

Table 37. Percentage error limits at reference conditions (single-phase metes and *Poly-Phase* meters with balanced load)

Value of current for direct connected or transformer operated meters	**Power factor**	**Percentage error limits for meters of class index**		
		A	**B**	**C**
$I_{tr} \leq I \leq I_{max}$	0,5 ind , 1	± 3,0	± 2,0	± 1,0

Table 38. Percentage error limits at reference conditions (*Poly-Phase* meters carrying a single phase-load with balanced load, but with balanced *Poly-Phase* voltages applied to voltage circuits

8.8.4 Initial start-up of the meter

The meter shall be functional within 5 s after the rated voltage is applied to the meter terminals.

8.8.5 Test of starting condition

The meter shall start and continue to register at the starting current values (and in case of *Poly-Phase* meters, with balanced load) shown in Table 39.
If the meter is designed for the measurement of energy in both directions, then the fulfilment of this requirement shall be verified with energy flowing in each direction.

Meters for	Power factor	Percentage error limits for meters of class index		
		A	B	C
Direct connection	1	0,05 I_{tr}	0,04 I_{tr}	0,04 I_{tr}
Connection through current transformers	1	0,06 I_{tr}	0,04 I_{tr}	0,02 I_{tr}

Table 39. Starting current

8.8.6 Test of no-load condition

When the voltage is applied with no current flowing in the current circuit the test output of the meter shall not produce more than one pulse.
For this test the current circuit shall be open circuit and a voltage of 115 % of the reference voltage shall be applied to the voltage circuits.
The minimum test period Δt shall be

$$\Delta t \geq \frac{240 \times 10^3}{k \times Utest \times Ist} min$$

Where:

- k → number of pulses emitted by the output device of the meter per kilowatt-hour (imp/kWh);
  Note: For transformer-operated meters with primary or half-primary registers, the constant k shall correspond to the secondary values (voltage and currents).
- m → number of measuring elements;
- U_{test} → test voltage in Volts – its value shall be *1,15* U_n;
- I_{st} → starting current.

8.8.7 Meter constant

The relation between the test output and the indication of the register shall comply with the marking on the name-plate. The difference of the percentage error determined from the test output and by reading the register shall be less than 1/10th of the limit of percentage error at reference conditions.

Note: This applies at a single test current.
This shall be verified by measuring a sufficient amount of energy, and observing the test output and reading the display.

8.8.7.1 Immunity to continuous magnetic fields of external origin

The test shall be performed using the electromagnet according to Figure 18, energized with d.c. current.

- meter in operating condition:
  - voltage and auxiliary circuits energized with reference voltage;
  - current and power factor as specified in the relevant standard;
- the value of the magneto-motive force shall be 1 000 At (ampere-turns);
- the magnetic field shall be applied to all accessible surfaces of the meter when it is mounted as for normal use.

During the test the behaviour of the equipment shall not be perturbed and the additional percentage error shall not exceed the critical change values specified in Table 40

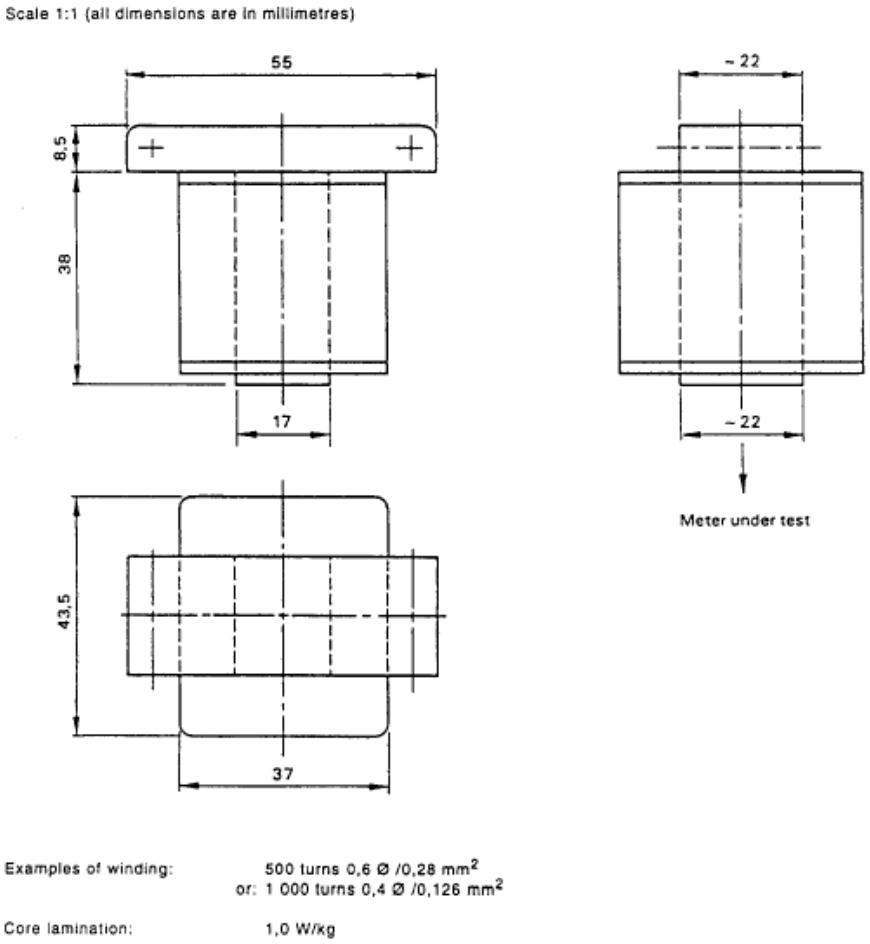


Figure 18. Electromagnet for testing the influence of continuous magnetic fields of external origin

Disturbance	Value	Value of current (balanced unless otherwise stated)	Power factor	Critical change value for meters of class index %

		For direct connected meters	For transformer operated meters		A	B	C
Continuous magnetic fields of external origin	1000 Ampere-turns	10 I_{tr}	I_n	1	± 3,0	± 2,0	± 1,0

Table 40. Critical change values for continuous magnetic fields of external origin

8.8.7.2 Immunity to power frequency magnetic fields of external origin

The test shall be carried out according to EN 61000-4-8, under the following conditions:

- tested as table-top equipment;
- induction coil as per Subclause 6.2.1.a) of EN 61000-4-8;
- immersion method;
- the current flowing through the coil shall be applied in the most unfavourable conditions of phase and direction compared to the voltage(s) energizing the meter;
- frequency equal to reference frequency;
- magnetic field applied in three perpendicular planes;
- meter in operating condition:
  - voltage and auxiliary circuits energised with reference voltage;
  - current and power factor as specified in the relevant standard;
- test with continuous field, field strength 0,5 mT;

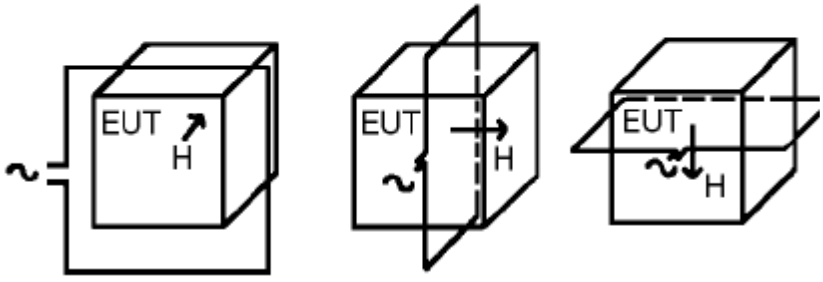


Figure 19: Example of application of the test field by the immersion method

During the test the behaviour of the equipment shall not be perturbed and the additional percentage error shall not exceed the critical change values specified in the Table 41, and in the Figure 19 there is a set-up for the test.

Disturbance	Value	Value of current (balanced unless otherwise stated)		Power factor	Critical change value for meters of class index %		
		For direct connected meters	For transformer operated meters		A	B	C
Power frequency magnetic fields of external origin	0,5 mT	10 I_{tr}	I_n	1	± 3,0	± 2,0	± 1,0

Table 41: Critical change values for power frequency magnetic fields of external origin

There is another part of this test and it is related to the verification that the sensor of the permanent magnets is insensitivity to this ac magnetic field. In Table 42 are described the value of power frequency magnetic fields

Level	Magnetic field strength (A/m)
5	1000

Table 42: Test level for short duration power frequency magnetic field: 1 s to 3 s

8.8.8 Test for sensitivity of permanent magnet

This test is made for evaluated the functionality of the meter to detect the permanent magnet field.

Test condition:

- meter in operating condition:
  - voltage and auxiliary circuits energised with reference voltage;
  - no load

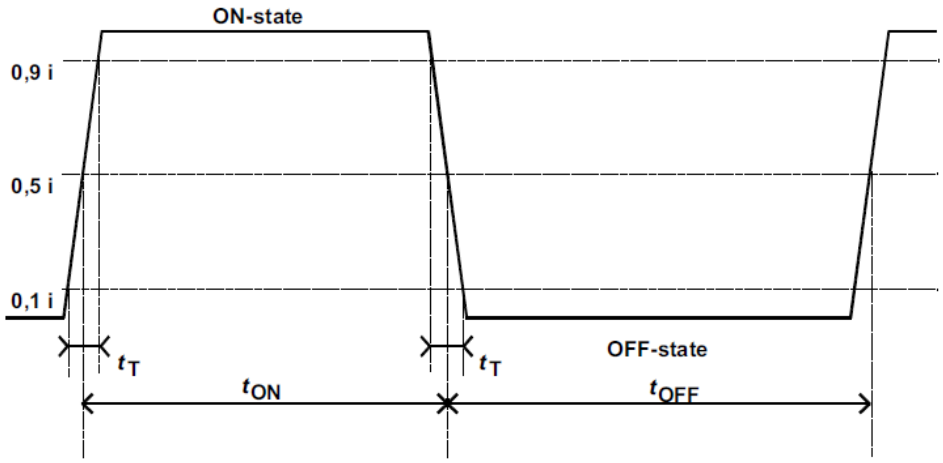
Test set-up:

- Put the permanent magnet on top of the meter and read the status word and evaluate:
  - Flag related to presence of magnetic field is set;
  - Register of presence of magnetic field increments the value.
- Put the permanent magnet on left side of the meter and read the status word and verify that:
  - Flag related to presence of magnetic field is set;
  - Register of presence of magnetic field increments the value.
- Put the permanent magnet on right side of the meter and read the status word and verify that:
  - Flag related to presence of magnetic field is set;
  - Register of presence of magnetic field increments the value.
- Put the permanent magnet close to the front side of the meter and read the status word and verify that:
  - Flag related to presence of magnetic field is set;
  - Register of presence of magnetic field increments the value.

Note: The register of presence of magnetic field, increments its value by one for each second that the permanent magnet is near to meter.

8.8.9 Mechanical and electrical characteristics on optical output

An optical test output shall be accessible from the front.
The maximum pulse frequency shall not exceed 2,5 kHz.
Modulated and unmodulated output pulses are permitted. The unmodulated output pulses shall have the shape shown in Figure 20.
The pulse transition time (rise time or fall time) is the time from one state to the other state, including transient effects. The transition time shall not exceed 20 µs (see Figure 20).
The distance of the optical pulse output from other adjacent ones, or from other optical devices, if any, (e.g. operation indicator, status indicator, communication port) shall be sufficiently long to avoid any interference.
An optimum pulse transmission is achieved when, under test conditions, the receiving head is aligned with its optical axis on the optical pulse output.
The rise time given in Figure 20 shall be verified by a reference receiver diode with tr µ 0,2 µs.



Requirements: $t_{ON} \geq 0{,}2$ ms ;

$t_{OFF} \geq 0{,}2$ ms ;

$t_T < 20$ µs

Figure 20: Waveform of the optical test output

8.8.10 Optical characteristics

The wavelength of the radiated signals for emitting systems is between 550 nm and 1 000 nm.

The output device in the meter shall generate a signal with a radiation strength ET over a defined reference surface (optically active area) at a distance of *a1 = 10 mm ± 1 mm* from the surface of the meter, with the following limiting values:

ON-condition: 50 µW/cm^2 ≤ ET ≤ 1 000 µW/cm^2

OFF-condition: ET ≤ 2 µW/cm^2

See also Figure 21.

Note: Where a meter uses a modulated output the ON condition value refers to the measurement when the output device is ON and not the average level over the modulated period.

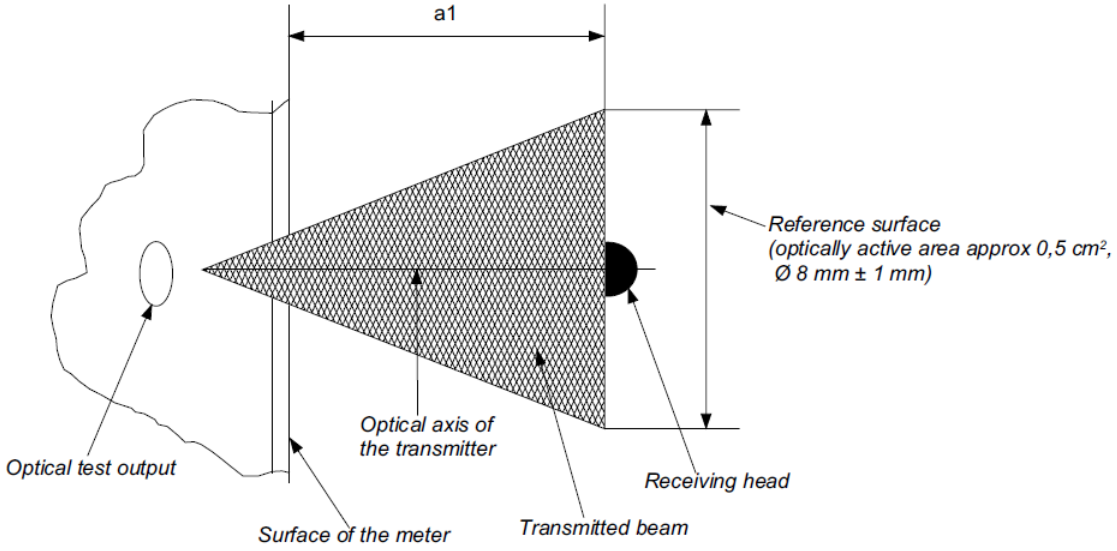


Figure 21: Optical test output

8.8.11 Tests of Clock and Clock Accuracy Requirements

The types of test are shown below. In order to perform these tests, it must be used a dedicated software prepared for the verification of the RTC and also the pc will have to be synchronized with a reference clock.

8.8.11.1 Test of crystal-controlled time switches supplied by mains

The time switch under test is supplied together with, and synchronized to, a reference crystal controlled clock. After a testing period of 30 days, the time-indication discrepancy between the reference clock and the time switch under test must be less than ±15 s.

8.8.11.2 Test of crystal-controlled time switches on operation reserve

The time switch to be tested is powered together with a reference clock. Before the test, the time switch shall be powered for a suitable length of time, so that the operation reserve is fully available.
The power supply of the time switch under test is switched off for 36 h. When the power supply is restored, the time-indication discrepancy between the reference clock and the time switch under test shall not be more than that calculated from the time-keeping accuracy on operation reserve multiplied by the length of the operating reserve.
Note: Consequently, the time indication discrepancy should be less than ±1,5 s.

The restoration of the voltage shall be made with the switching device free from bounce.

8.8.11.3 Test of influence of harmonics

The time switch is supplied together with, and synchronized to, a reference clock. Ten per cent of the third harmonic is added to the power supply voltage of the time switch under test. The test is carried out over 30 days. At the end of the test, the time-indication discrepancy between the time switch under test and the reference clock shall be less than ±7 s for synchronous time switches and less than ±17 s for crystal-controlled time switches.

8.8.11.4 Effect of short-supply interruptions on synchronous time switches

The time switch under test is submitted to a sequence of 20 successive supply interruptions with at least 5 s intervals between these interruptions. The value of interruptions to be applied shall be 20 ms, 50 ms, 100 ms, 200 ms, 500 ms, 1 s and 2 s.
After each test, the time indication discrepancy between the time switch under test and the reference clock shall be less than the value shown in Table 43.

Supply interruption length	20 ms	50 ms	100 ms	200 ms	500 ms	1 s	2 s
Maximum time indication discrepancy	400 ms	1 s	2 s	4 s	10 s	10 s	10 s

Table 43. Maximum inaccuracies

8.8.11.5 Test of time-keeping accuracy of crystal-controlled time switches with temperature

The time switch is placed in a climatic chamber and its time base is measured at +23 °C.
The temperature is set at +45 °C. After thermal equilibrium is obtained, the time-keeping accuracy shall be better than ±3,3 s/24 h plus the time-keeping accuracy measured a reference temperature (max. +0,5 s/24 h).

*Note: The accuracy of the time base should not differ from the 23 °C measurement by more than ±38*10–6.*

The temperature is then set at –10 °C. After thermal equilibrium is obtained the time-keeping accuracy shall be better than ±4,95 s/24 h plus the time-keeping accuracy measured at reference temperature (max. +0,5 s/24 h).

*Note: The accuracy of the time base should not differ from the 23 °C measurement by more than ±57*10–6.*

8.9 Durability Test

The stability of metrological characteristics is one important aspect of durability.

The IEC 62059-32-1 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.

Functional performance other than the accuracy of energy measurement is out of the scope of this standard.

8.9.1 Initial measurements

The percentage error of the MUT shall be measured – using the test output of the MUT and appropriate test equipment – at the following test points:

- value of voltage: Un;
- value of current for direct connected meters: 0,1 Ib, Ib and Imax;
- value of current for transformer operated meters: 0,05 In, In and Imax;
- value of power factor for meters for active energy: cos φ = 1 and cos φ = 0,5 inductive;
- value of power factor for meters for reactive energy: sin φ = 1 and sin φ = 0,5 inductive.

The accuracy test conditions shall be as specified in CEI EN 50470-1/3.

8.9.2 Conditioning

The meter shall be exposed to the elevated temperature according to IEC 60068-2-2 as follows:

- test Be: dry heat for heat-dissipating specimens with gradual change of temperature that are required to be powered throughout the test;
- air velocity: low preferred (see IEC 60068-2-2, 4.2);
- temperature: the upper limit of the operating temperature range specified by the manufacturer;
- duration of the test: 1 000 h;
- Meter under test in operating conditions, with test load:
  - value of voltage: 1,1 Un. If the meter is intended for several reference voltages, then the highest reference voltage shall be taken into account; => 253 Vac
  - value of current: Imax
  - value of power factor:
    - the meter measures both active and reactive energy, then the value of the power factor shall be cos φ = 0,866 (sin φ = 0,5) inductive.

8.9.3 Verification of energy measurement and registration

During the conditioning, it shall be verified that the meter does not exhibit any irregular behaviour in energy measurement and registration.

To verify this, the percentage error of the energy registration shall be determined at the test load, using the following formula:

$$Percentage\ error = \frac{energy\ registered\ by\ the\ meter - true\ energy}{true\ energy}\ x\ 100$$

The energy registered by the meter during a given interval is read from the register of the meter.

For the evaluation of the error true it is requirede to use a double methodology as explained subsequently:

Using a reference meter and using a reference meter of the same type as meter under test.

The reference meter is installed outside the test chamber, exposes to the same load as the meter under test. The true energy is determined by reading this reference meter.

The test conditions shall be the following:

- voltage: 1,1 Un + 2 % …- 5 %;
- voltage balance (in the case of polyphase meters): ± 2 %;
- current: Imax + 2 % …- 5 %;
- current balance (in the case of polyphase meters): ± 4 %;
- phase displacement of each phase current from the corresponding phase-to-neutral
- voltage irrespective of the phase angle: 4°;
- power factor: corresponding to ± 4°;
- overall tolerance of the test load: ± 5 %;
- the laboratory temperature shall be 23 °C ± 2 °C.

In this case, a reference standard meter shall be used.

NOTE: The measurement errors of this meter should be negligible compared to the error limits of the meter under test.

The limit of the percentage error, calculated using the formula in 7.1 is:

$$e_{max} = \sqrt{e_o^2 + e_U^2 + e_T^2}$$

where:

- e_o is the limit of the percentage error at the test load and at the reference conditions;
- e_U is the limit of variation in percentage error due to voltage variation;
- e_T is the limit of variation in percentage error due to temperature variation,
- e_o and e_T are specified in the standard CEI EN 50470-1/3.

If the meter is for active and reactive energy, then the test, as specified in paragraph 5.9.2, shall be performed at cos φ = 0,866 (sin φ = 0,5) inductive. For the values of e_o, e_U and e_T, the values relevant for cos φ = 0,5 and sin φ = 0,5 shall be taken into account.

If the percentage error exceeds e_{max}, this indicates that the behaviour of the meter under test is irregular. The meter under test failed and the test can be terminated.

At the same time, outside of climatic chamber it is required to put another meter that is the same type of the meter that is under test.

NOTE 1 It is assumed, that the behaviour of the meter under test and the reference meter in the presence of influence quantities and disturbances is similar.

NOTE 2 Special care should be taken to ensure that the load on the reference meter and the MUT is the same. In the case of meters, where the voltage and current circuits cannot be separated, the

voltage circuits of the meter under test and the reference meter should be supplied via appropriate multi-secondary voltage transformers, so that the test conditions are met.

Before the test, the percentage error of the reference meter at the test load (1,1 Un, Imax) shall be determined. The absolute value of this percentage error is denoted e_r.

The limit of the percentage error, calculated using the formula :

$$e_{max} = \sqrt{(e_o + e_r)^2 + e_T^2}$$

where:

- e_o is the limit of the percentage error at the test load and at the reference conditions;
- e_r is the absolute value of the percentage error of the reference meter at the test load;
- e_T is the limit of variation in percentage error due to temperature variation.

e_o and e_T are specified in the 50470-1/3 standards.
If the meter is for active and reactive energy, then the test, as specified in paragraph 5.9.2, shall be performed at cos φ = 0,866 (sin φ = 0,5) inductive. For the values of e_o and e_T, the values relevant for cos φ = 0,5 and sin φ = 0,5 shall be taken into account.
If the percentage error exceeds e_{max}, this indicates that the behaviour of the meter under test is irregular. The meter under test failed and the test can be terminated.

8.9.4 Set-up

In the following Figure 22 are presented only the position of the meters and the wattmeter.

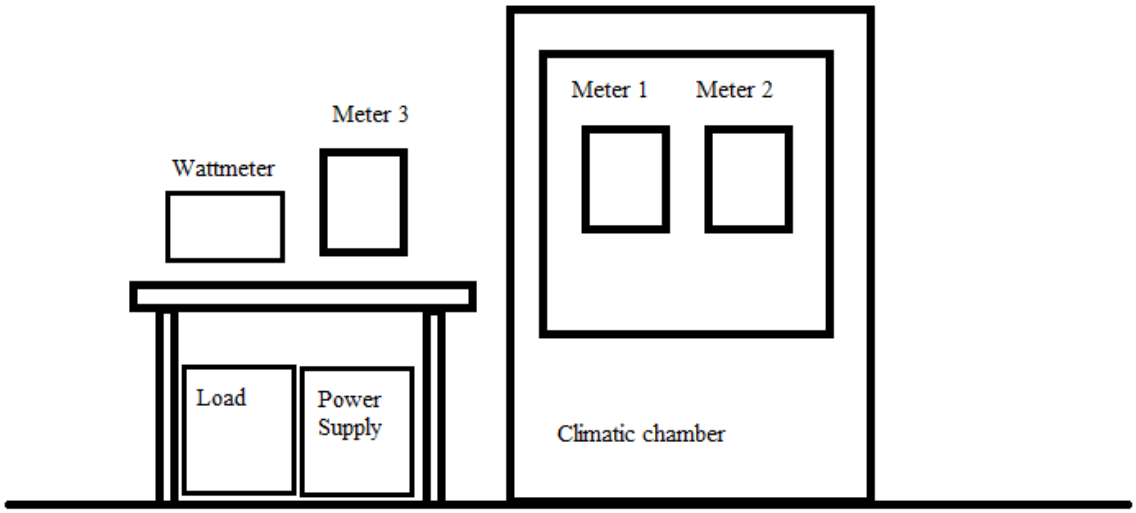


Figure 22: Set-up of the meters under test

In the climatic chamber there are two meter connected in series, outside there is another also connected to the series of the two meter in the climatic chamber; all three meter are then connected to the same load, and then they are subjected to the same condition of load. The same thing are made for the power supply.
The wattmeter is connected in a way that it can record the energy that circulated in the meters.
In the previous chapters are given the information about the condition of temperature, voltage, current length of cables and the methods for calculate the error.

8.10 Heating

The test is intended to ensure that accessible surfaces and parts of the metering equipment do not exceed the temperature limits specified in the test 8.10.1 and 8.10.2 and that the manufacturer's temperature limits of safety-relevant parts are not exceeded.

8.10.1 Surface temperature limits for protection against burns

At an ambient temperature of 40 °C, the temperature of easily touched surfaces shall not exceed:

a) the values of Table 44 in normal condition (this test is based on 62052-31/FIDIS); and
b) The temperature rise of the external surface shall not exceed 25 K, with an ambient temperature of 40 tu and in normal condition. During the test, the duration of which shall be 2 h (this test is based on 50470-1).

Surfaces of the terminal blocks covered by terminal covers or, in the case of panel mounted meters, protected by a barrier are not considered to be easily touched surfaces.

Part	Limit °C
1) Outer surface of enclosure (unintentional contact)	
a) metal, uncoated or anodized	65
b) metal, coated (paint, non-metallic)	80
c) plastics	85
d) glass and ceramics	80
e) small areas (<2 cm^2) that are not likely to be touched in normal use	100
2) Knobs and handles (normal use contact)	
a) metal	55
b) plastics	70
c) glass and ceramics	65
d) non-metallic parts that in normal use are held only for short periods (1 s – 4 s)	70

Table 44: Surface temperature limits in normal condition

Normal condition means:

- Equipment shall be tested built in as specified in the installation instructions, using walls of plywood painted matt black, approximately 10 mm thick when representing the walls of a cabinet, approximately 20 mm thick when representing the walls of a building.
- The test shall be performed under reference conditions, with ambient temperature 23 °C ± 2 °C at the start of the test with each voltage circuit (and with those auxiliary voltage circuits which are energized for periods of longer duration than their thermal time constants) carrying 1,15 times the reference voltage and:
  - in the case of single phase two-wire meters, both the phase and the neutral conductor carrying rated maximum current;
  - in the case of three-phase four-wire meters each current circuit carrying rated maximum current with the neutral conductor not carrying current;

The test shall be maintained until thermal stabilization has been reached. That is, when three successive readings, taken at intervals of 10 % of the previously elapsed duration of the test and not less than 10 min. intervals, indicate no change in temperature, defined as ± 1 °C between any of the three successive readings, with respect to the ambient temperature.

The maximum temperature attained shall be corrected to the rated maximum ambient temperature of the metering equipment by adding the difference between the ambient temperature attained during the test and the rated maximum ambient temperature.
For these two tests relating to the heating the thermal sensors shall be placed in the most relevant parts of the meter, depending on the mechanical design, shape and the position of parts that generate heat during the test.

8.10.2 Temperature for internal parts

The components, parts and materials of the equipment shall not attain temperatures in excess of those in Table 45 when the equipment is operated in accordance with its ratings.
The equipment shall be is tested in worst case conditions, applying the maximum current I_{max} and the maximum rated voltage, with all optional accessories powered.
The maximum measured temperatures shall be corrected by adding the difference between the ambient temperature during the test and the rated maximum ambient temperature of the equipment.

	Materials and components	Thermocouple method °C		Rise of resistance method °C	
1	Rubber- or thermoplastic-insulated conductors [a]	75			
2	Copper bus bars and connecting straps	[b]			
3	Insulation systems on magnetic components (windings) [c]	[d]		[d]	
	Class of insulation (See IEC 60085)	Normal condition	Single fault condition	Normal condition	Single fault condition
	Class A (105)	90	135	100	145
	Class E (120)	105	150	115	160
	Class B (130)	110	155	120	165
	Class F (155)	130	165	140	175
	Class H (180)	155	185	165	195
4	Phenolic composition [a]	165			
5	On bare resistor material	415			
6	Capacitor	[e]			
7	Power electronic devices	[f]			
8	PWBs	[g]			
9	Components bridging at least basic protection	[e]			
10	Batteries	[e]			

[a] The limitation on rubber and thermoplastic insulation and phenolic composition does not apply to compounds which have been investigated and found to meet the requirements for a higher temperature.

[b] The maximum permitted temperature is determined by the temperature limit of support materials or insulation of connecting wires or other components. A maximum temperature of 140 °C is recommended.

[c] The maximum temperatures on insulation of magnetic components assume thermocouples are applied on the surface of coils, and are therefore not located on hot-spots. Rise of resistance method results in a measurement of the average temperature of the winding.

[d] These limits are extracted from the group safety standards IEC 61558-1 and IEC 61558-2-16 (Safety of power transformers, power supplies, reactors and similar products).

[e] For a component, the maximum temperature specified by the manufacturer should not be exceeded.

[f] The maximum temperature on the case should be the maximum case temperature for the applied power dissipation specified by the manufacturer of power electronic devices.

[g] The maximum operating temperature of the PWB shall not be exceeded.

Table 45: Maximum measure total temperatures for internal materials and components

To determine the temperature rise of a winding by the change of resistance method the following formula shall be used

$$\Delta t=(_{R2-R1/R1})(k+t_1)-(t_2-t_1)$$

where:
Δt is the temperature rise above t_2 so that the maximum temperature equals to $\Delta t+t_2$
R_2 is the resistance at the end of the test in ohms;
R_1 is the resistance at the beginning of the test in ohms;
t_1 is the ambient temperature at the beginning of the test (ºC);
t_2 is the ambient temperature at the end of the test (ºC);
k is 234,5 for copper, 225,0 for electrical conductor grade (EC) aluminium. Values of the constant for other conductors shall be determined.

The position of the thermocouples will be indicated before the test.

8.11 DLC verification

In this chapter are described the tests for verify the conformity of the meter's modem DLC to the requirements.

8.11.1 Transmit performance verification

Use the set-up show in Figure 23 to verify the transmit output level.

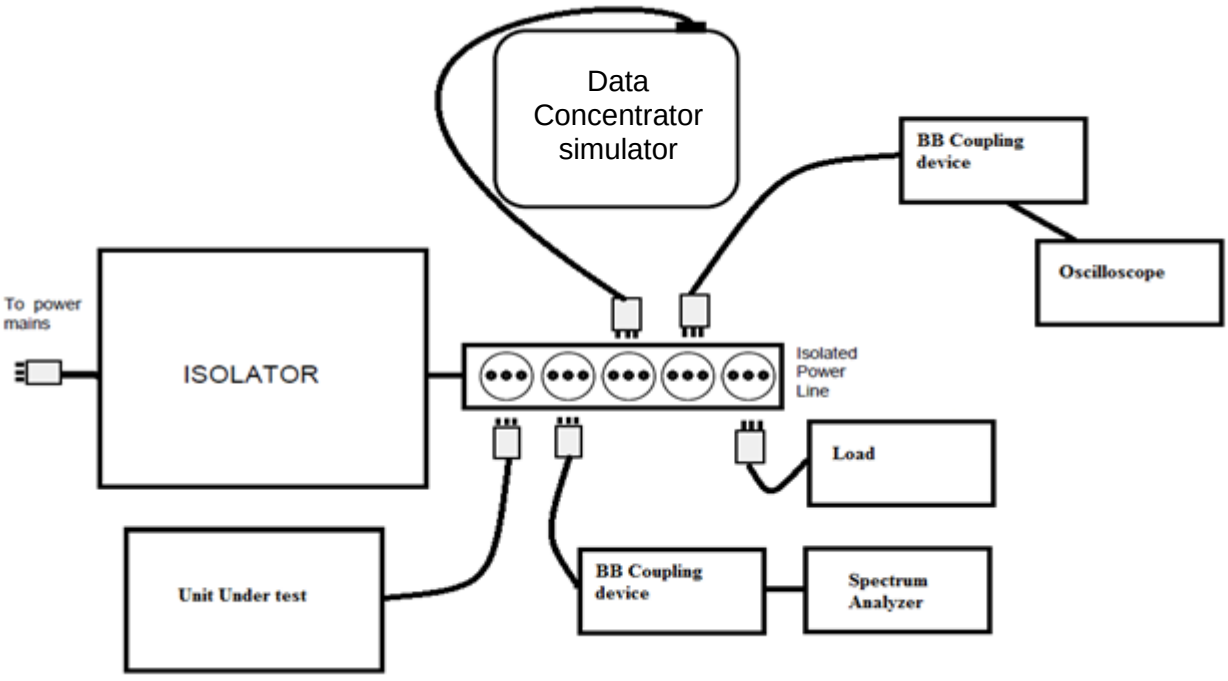


Figure 23: Set-up for sensitivity performance

Other set-up information:

- Data Concentrator Simulator: it is a device that will be provided by Enel Grids

- Load: 5,0 Ω

Pass/fail criteria: Tx Level ⩾ 1,5 $V_{rms;}$

Using the same setup is carried out also the measure of sensitivity of the modem:

Setting of transmitter:
- Level of transmitter: 54 dBµV;
- Number of packet send: 1000;

The criteria of acceptance is below defined:
- Error expected ≤ 1%.

8.11.2 Unintentional output noise verification

This set-up is important to determine if the UUT is generating unwanted noise which may impede its communication performance or that of other device on the power mains

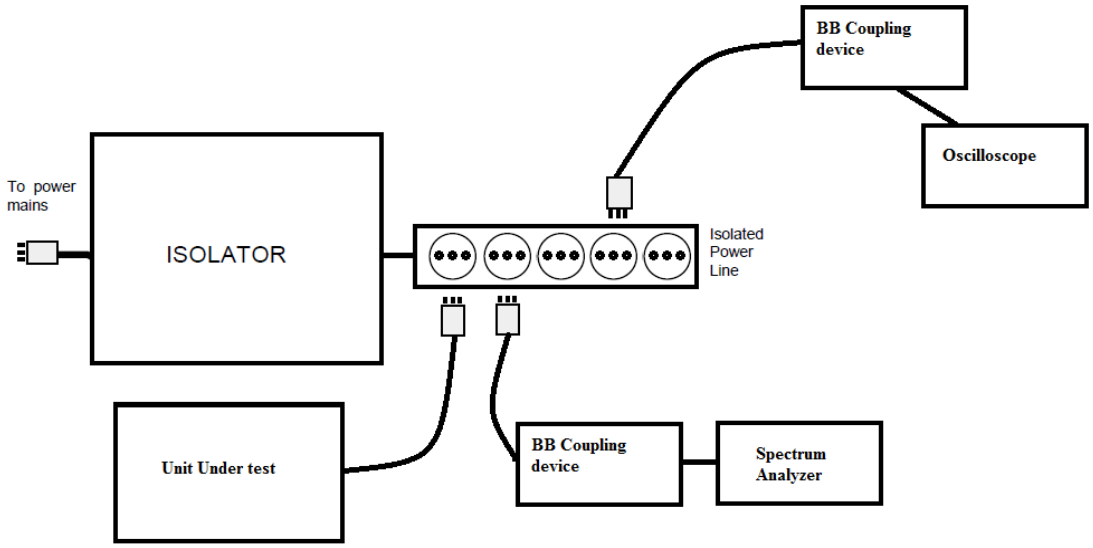


Figure 24: Unintentional output noise verification

8.11.3 Verification of the DLC signal when increase the impedance

Use the set-up in Figure 25 to understand which is the value of impedance that the modem be able to drive before the transmitting level decreasing.

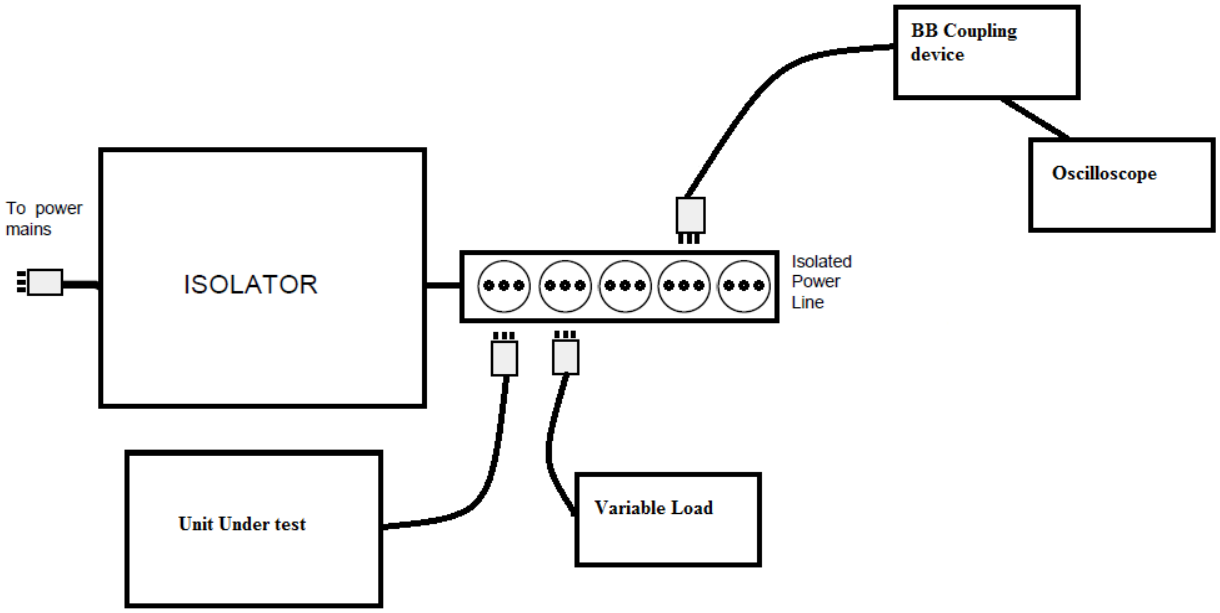


Figure 25: Set-up of verification output level of DLC signal when the impendence on the net increases

8.12 169 MHz verification

This section shows the set-up to carry out the verification of communication in 169 MHz. This verification is required only for the meters that integrate Radio Frequency module.

8.12.1 Verification of the diagram radiation

The test must be carried out in an anechoic chamber (semi-anechoic or fully anechoic); below are indicated the parameters of test:

- Distance between meter and receiver antenna: 3 m;
- Rotation receiver antenna: from 0° to 360;
- Rotation step: 10°;
- Height of receiver antenna: 2 m;
- Temperature: 23°C;
- Humidity: 50%;
- Pressure: 1004 mbar;

The height of the meter must be calculated so that the centre of the 169 MHz transmitter antenna is at the same height of the receiving antenna.
The axis of the 169 MHz meter antenna was maintained perpendicular to the reference plane and aligned in the centre of the turning table.
The set up is shown in Figure 26.
The meter must be able to transmit continuously with a given duty cycle.

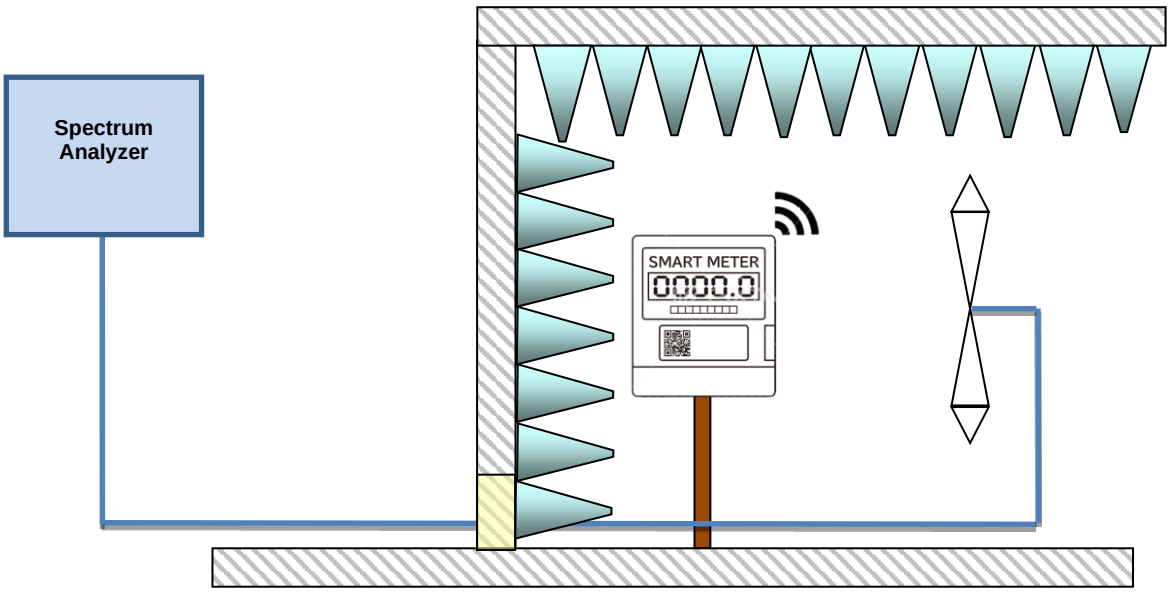


Figure 26: Set up for radiation diagram.

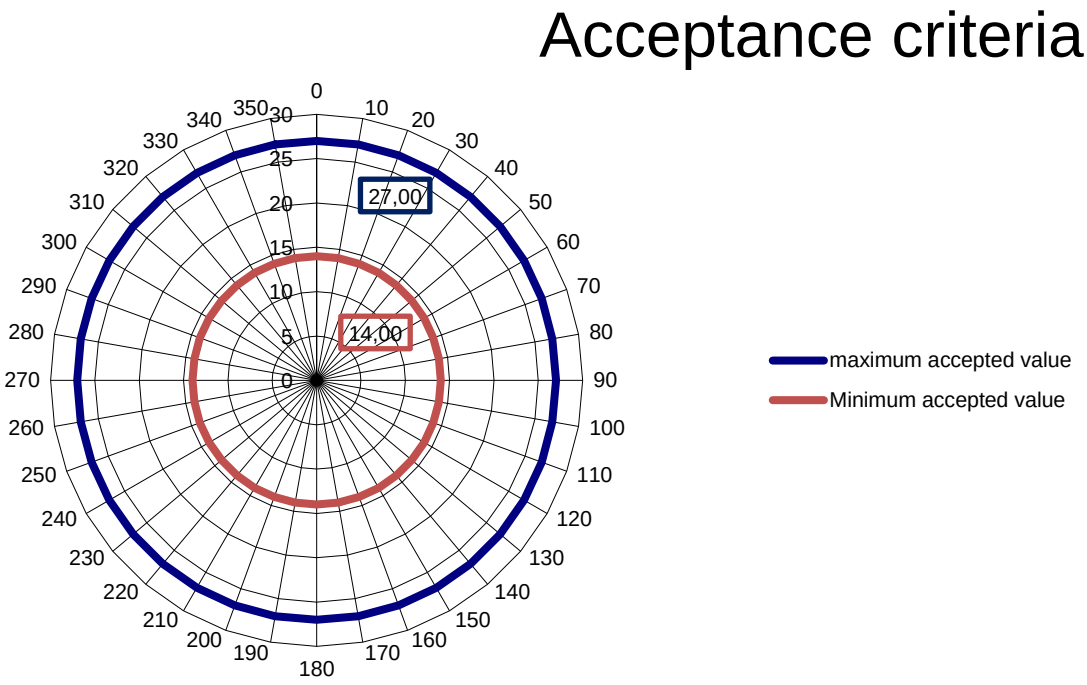


Figure 27: Acceptance criteria for 169 MHz module

If the radiated power is between the values shown in the Figure 27 the 169 MHz module is working efficiently.

8.12.2 Testing of sensitivity in reception mode

The test must be carried out in an anechoic chamber (semi-anechoic or fully anechoic); below are indicated the parameters of test:

- Distance between meter and transmitter antenna: 3 m;
- Height of transmitter antenna: 2 m;
- Temperature: 23 °C;
- Humidity: 50%;
- Pressure: 1004 mbar

The height of the meter must be calculated so that the centre of the 169 MHz antenna is at the same height of the transmitter antenna.
The axis of the 169 MHz meter antenna was maintained perpendicular to the reference plane and aligned in the centre of the turning table.
The set-up is shown in Figure 28.

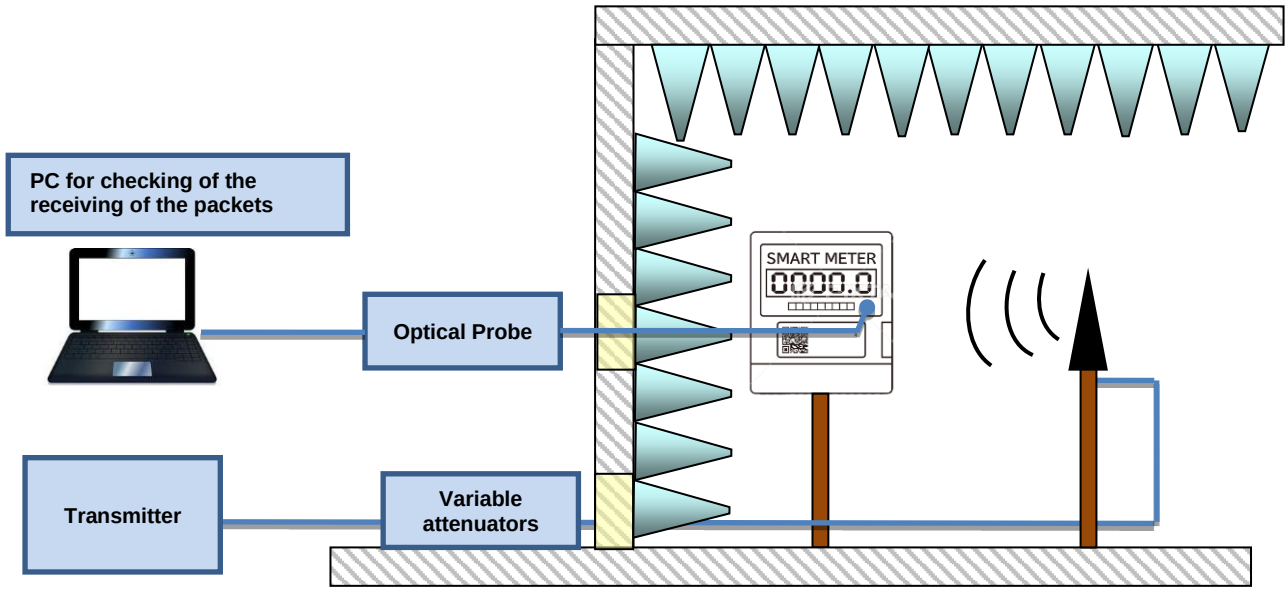


Figure 28: Set up for reception sensitivity of 169 MHz module

The acceptance criteria is:

- Reception sensibility ≥ -100 dBm (N mode)

8.13 Test for shipping meter

This test method covers the random vibration testing of filled shipping units. Such tests may be used to assess the performance of a container with its interior packaging and means of closure in terms of its ruggedness and the protection that it provides the contents when subjected to random vibration input. Vibration exposure affects the shipping container. Its interior packaging, means of closure, and contents. This test allows to analysis of the interaction between these components. Design modification to one or all of these components may be used to achieve optimum performance in the shipping environment.

Definition:

- **Sample:** In this test the sample is **Box of meters** (in the box there are 4, 5 or 6 meters depending of the typology of meter);
- **P.S.D:** Power Spectral Density an expression of random vibration in term of mean square acceleration per unit of frequency [g^2/Hz]

Test set-up

- The sample centre of gravity should be as near as practicable to the centre of the table;
- The sample allowed to vibrate freely (attach restraining device to the vibration table to prevent excessive rocking and movement off the vibration table; approximately 10 mm in any horizontal direction);
- Vibration only on Z axis;
- Frequency range: 1 ÷ 200 Hz;
- Test profile: Truck (see Figure 29);
- Acceleration level: 0,517 g RMS;
- Duration of test: 30 min.

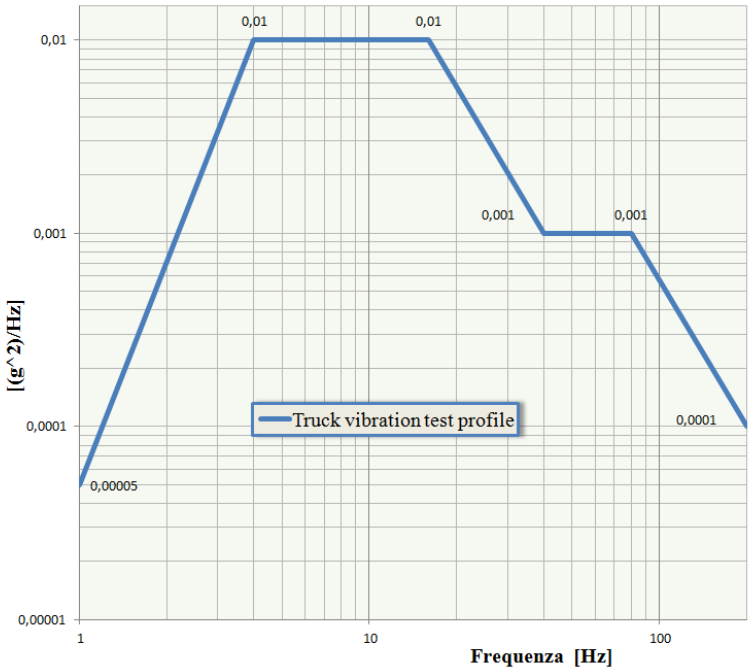


Figure 29: P.S.D curve of transport vibration test profile

There are not a real evaluation criterion , at the end of the test will evaluate the condition of the meter inside the box, in particular the focus will be on:

- Position of the cut-off device’s screws;
- Condition of the plastic case;
- Integrity of the case.

9 SAFETY

It is required that the meter satisfy product safety requirements specified in IEC 62052-31:2015 considering the following assumption:

- Rated impulse voltage: 6000V CATIII
- Utilization Category: UC3

10 ANNEX A

10.1 Additional Accuracy Test with Switched Loads and Current with High Harmonic Content

This Annex specifies the test conditions to be applied to LV static meters in order to verify its accuracy characteristics when connected to switched loads or to loads producing heavy harmonic distortion.

The test conditions here described have to be considered as an integration of the requirements specified in CEI EN 50470-1.

These additional requirements applies to meters for direct connection (as well as to meters intended to be installed via external current transformers. In this last case the parameter I_b specified in the following clauses is to be replaced by I_n).

10.1.1 A1 - TESTS WITH SWITCHED LOADS

The test conditions described in the following have the purpose to cover the operating conditions of meters supplying loads switched by electromechanical devices as well as loads switched/controlled by electronic modules.

The actual operating conditions of the meters installed in the LV networks may be very changeable due to the unpredictable combination of different loads.

The current values can change from zero or from any possible values up to the I_{max} of the meter; also the switching time of the loads and the repetition rate (if any) can range without limits.

In order to verify the accuracy of the meter when subjected to these operating conditions, a set of current profiles are specified in the following as representative of realistic condition.

The profiles are composed by two different current level; the current is switched from one value the other with a defined timing.

The main parameters of the test current profile are listed here below and specified in Table A1.

- I_L : low level current;
- I_H : high level current;
- T_L : duration of the I_L load condition;
- T_H : duration of the I_H load condition.

The test set up can be easily realized by using different loads and a suitable switching device; the switching of the loads at the current zero crossing is preferred.

In order to simultaneously cover active and reactive accuracy verification, loads with cosφ=0,7 can be used.

The test shall cover at list the combination of parameters specified in the following Table A1.

Test n.	I_L and related T_L	I_H and related T_H	Rep. Freq.
1	0 for 900 ms	I_b for 100 ms	1 Hz
2	0 for 900 ms	$5*I_b$ for 100 ms	1 Hz
3	I_b for 500 ms	$5*I_b$ for 500 ms	1 Hz
4	I_b for 100 ms	$5*I_b$ for 900 ms	1 Hz
5	$5*I_b$ for 500 ms	I_{max} for 500 ms	1 Hz
6	0 for 100 ms	$5*I_b$ for 100 ms	5 Hz
7	I_b for 100 ms	$5*I_b$ for 100 ms	5 Hz
8	I_b for 1 s	$5*I_b$ for 4 s	0,2 Hz
9	I_b for 1 s	I_{max} for 4 s	0,2 Hz

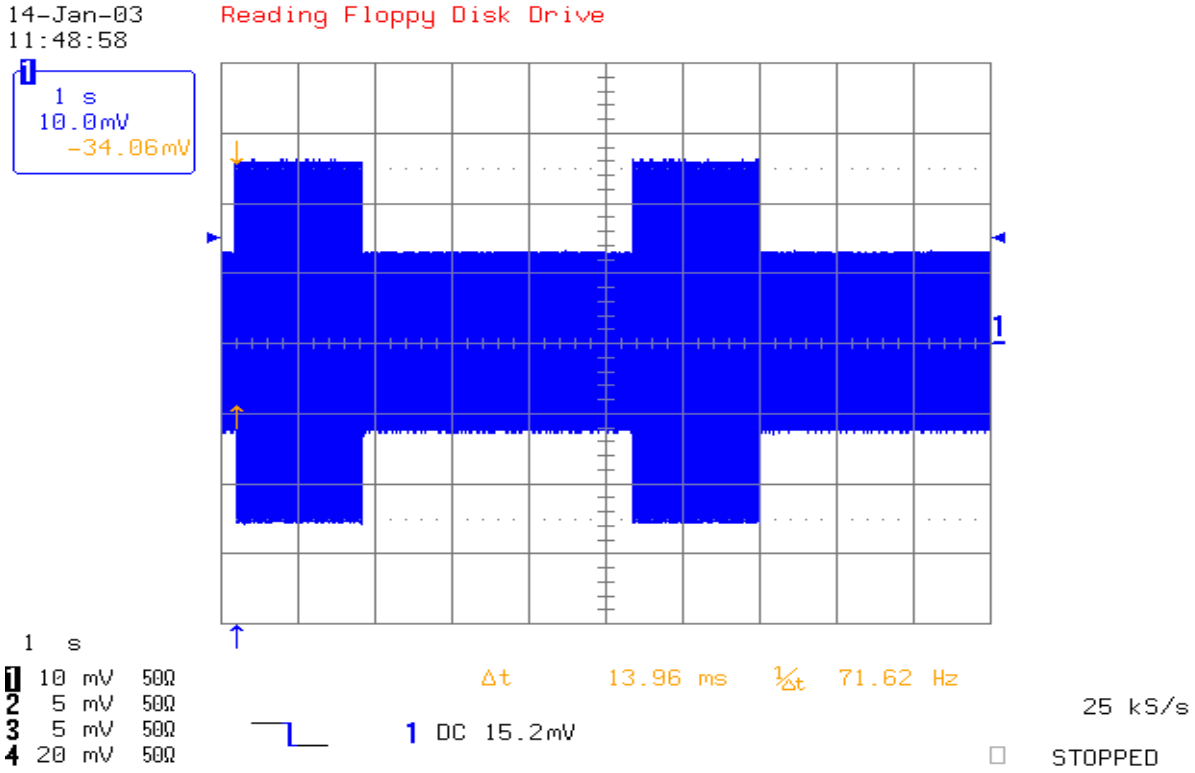
Table A1. Parameters

Test specification code: GRI-GRI-TST-E&C-0001

Version no. 1 dated 14/04/2023

Subject: GSSMC001 **-** Tests and Test conditions of static meters

Application Areas
Perimeter: *Global*
Staff Function: -
Service Function: -
Business Line: *Enel Grids*



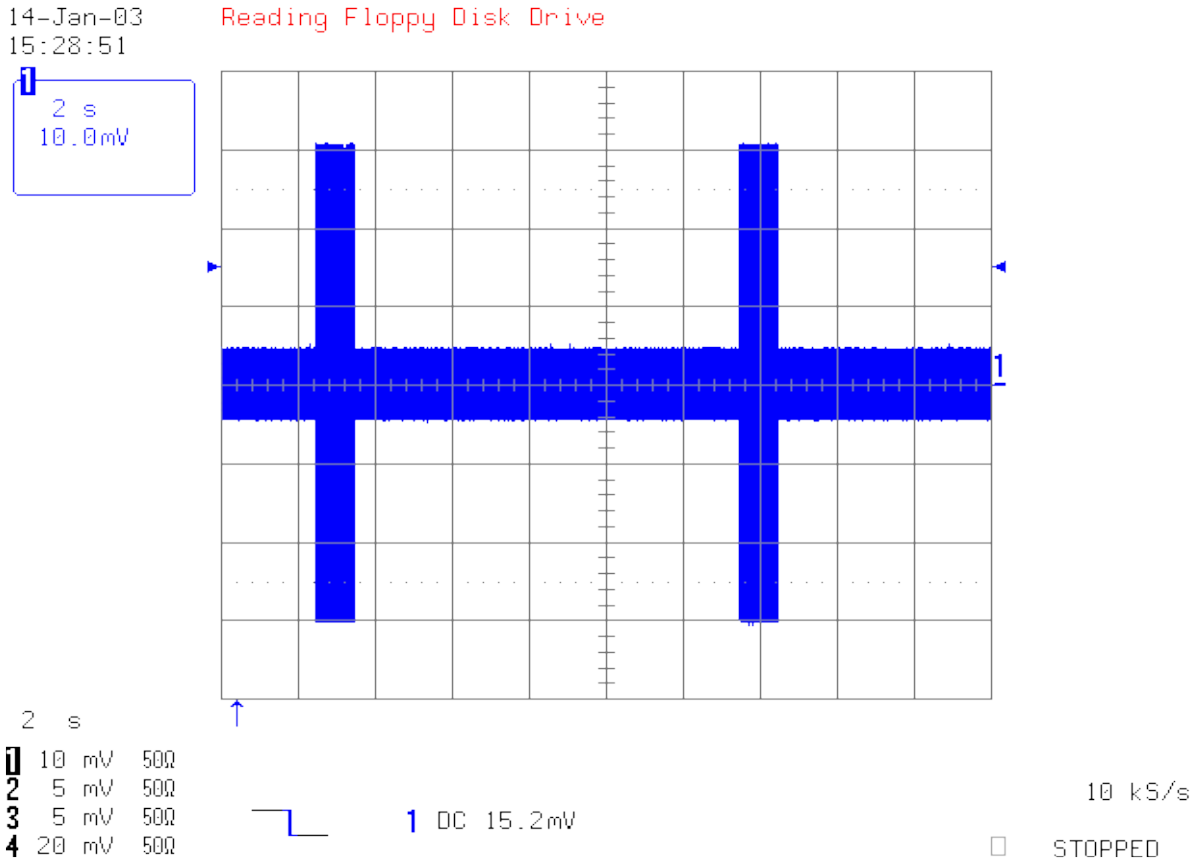


Fig. A 1. Examples of current profile produced by switched loads.

10.1.2 A2 - CURRENT WITH HIGH HARMONIC CONTENT

10.1.2.1 **A2.1 – D.C. AND EVEN HARMONICS (half wave rectification)**

The test condition and test procedure are specified in CEI EN 50470-3 Annex C.

In addition to this requirement, the test shall be carried out at the following reference current (full sine wave): $0.2I_b$, $0,5I_b$, I_b, $2I_b$, $5I_b$, I_{max} .

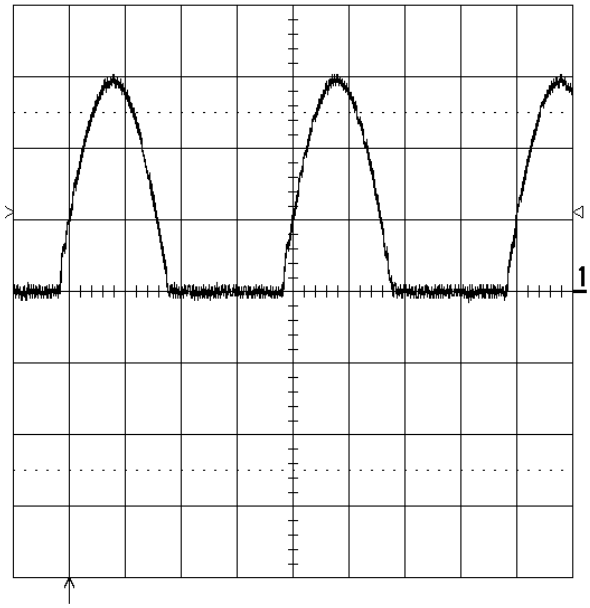


Fig. A 2. Current generated by half wave rectification.

10.1.2.2 A2.2 – Phase-fired waveform

The test condition and test procedure are specified in CEI EN 50470-3 Par.8.7.7.9

In addition to this requirement, the test shall be carried out at the following reference current (full sine wave): $0.2I_b$, $0,5I_b$, I_b, $2I_b$, $5I_b$, I_{max}

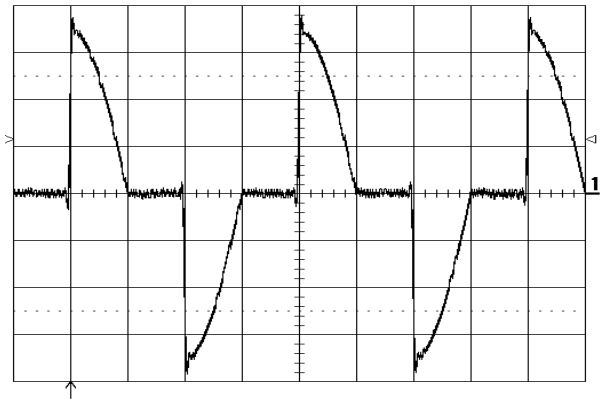


Fig. A 3. Current with Phase-fired waveform.

10.1.2.3 **A2.3 – Burst current waveform (burst control)**

The test condition and test procedure are specified in CEI EN 61000-4-4.

In addition to this requirement, the test shall be carried out at the following reference current (full sine wave: $0.2I_b$, $0,5I_b$, I_b, $2I_b$, $5I_b$, I_{max}

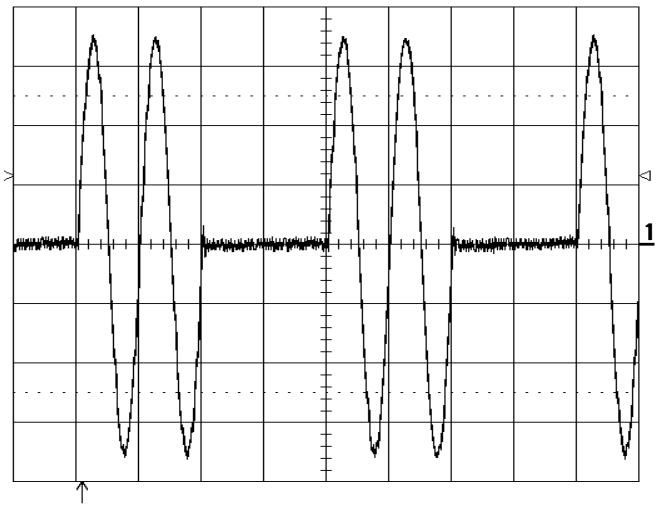


Fig. A 4. Burst current waveform.

A.2.4 – REPETITIVE PULSE CURRENT

The meter shall be verified when subjected to repetitive pulse current as represented in Fig. A 5.

The width of the pulse current, measured at the base, is 1 ms or 2 ms.

The test shall be carried out with the two waveform above at the following currant (peak value: $0.2I_b$, $0,5I_b$, I_b, $2I_b$, $5I_b$, I_{max}.

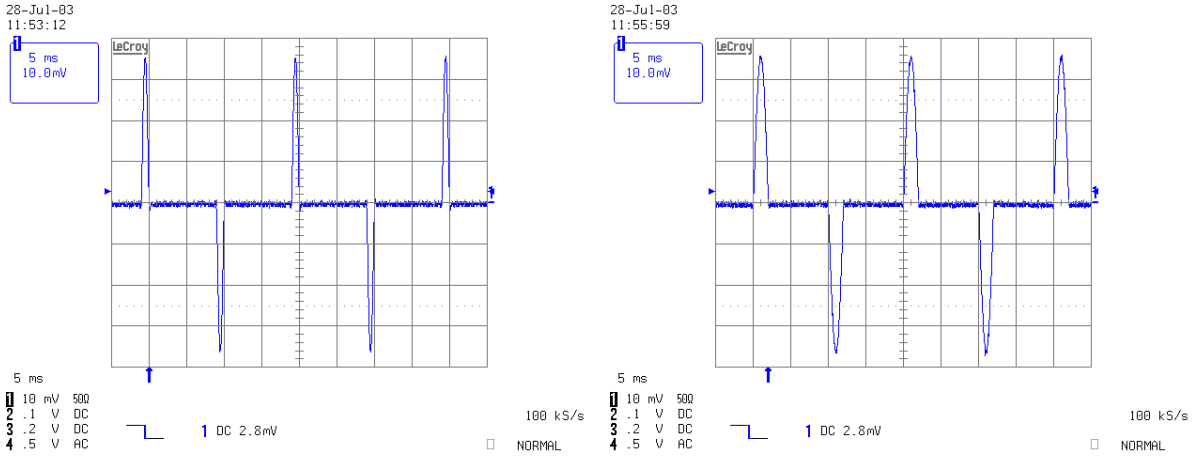


Fig. A 5. Repetitive pulse current.