

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Electrical energy meters – Test equipment, techniques and procedures –
Part 1: Stationary meter test units (MTUs)**

**Compteurs d'énergie électrique – Équipements, techniques et procédures
d'essai –**

Partie 1: Bancs d'essai stationnaires des compteurs d'énergie électrique (MTU)



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NORME INTERNATIONALE

**Electrical energy meters – Test equipment, techniques and procedures –
Part 1: Stationary meter test units (MTUs)**

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d'essai –
Partie 1: Bancs d'essai stationnaires des compteurs d'énergie électrique (MTU)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 17.220.20; 91.140.50

ISBN 978-2-8322-6437-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL ENERGY METERS –
TEST EQUIPMENT, TECHNIQUES AND PROCEDURES –****Part 1: Stationary meter test units (MTUs)****FOREWORD**

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Draft	Report on voting
13/1879/FDIS	13/1886/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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ELECTRICAL ENERGY METERS – TEST EQUIPMENT, TECHNIQUES AND PROCEDURES –

Part 1: Stationary meter test units (MTUs)

1 Scope

This part of IEC 62057 applies to stationary meter test units (MTUs) permanently installed in laboratories, used for testing and calibration of electricity meters, in particular for their type test, acceptance test and verification test. It covers the requirements for automatic MTUs for indoor laboratory application and applies to newly manufactured MTUs to test electricity meters on 50 Hz or 60 Hz networks with an AC voltage up to 600 V (phase to neutral).

If meters are intended for system voltages not specified in this document, special requirements are agreed between the manufacturer and the purchaser.

This document also defines the kind of tests to perform as type tests / routine tests / acceptance tests and commissioning tests for MTUs.

It does not apply to:

- portable reference meters and portable sources;
- electricity meters;
- data interfaces to the meter and test procedures of data interface;
- transformer operated MTUs;
- personal computers supplied together with the MTU.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 60617, *Graphical symbols for diagrams* (available at <http://std.iec.ch/iec60617>)

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60721-3-2:2018, *Classification of environmental conditions – Part 3-2: Classification of groups of environmental parameters and their severities – Transportation and handling*

IEC 60721-3-3:2019, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weatherprotected locations*

IEC 61010-031:2015, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 031: Safety requirements for hand-held probe assemblies for electrical measurement and test*
IEC 61010-031:2015/AMD1:2018

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61326-1:2020, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 62052-11:2020, *Electricity metering equipment – General requirements, tests and test conditions – Part 11: Metering equipment*

IEC 62052-31:2015, *Electricity metering equipment (AC) – General requirements, tests and test conditions – Part 31: Product safety requirements and tests*

IEC 62053 (all parts), *Electricity metering equipment*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016
CISPR 11:2015/AMD2:2019

EN 50160, *Voltage characteristics of electricity supplied by public electricity networks*

EN 50470 (all parts), *Electricity metering equipment (a.c.)*

ISO 3864-1:2011, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

ISO 7000, *Graphical symbols for use on equipment – Registered symbols* (available at <http://www.graphical-symbols.info/equipment>)

ISO 13732-1:2006, *Ergonomics of the thermal environment – Methods for the assessment of human responses to contact with surfaces – Part 1: Hot surfaces*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 Definitions related to the elements of the MTU

3.1.1

device under test

DUT

meter intended to measure active and/or reactive energy by integrating active and/or reactive power with respect to time

Note 1 to entry: For the definition of various types of energy meters and their elements, see IEC 62052-11:2020, IEC 62053-21:2020, IEC 62053-22:2020, IEC 62053-23:2020, and IEC 62053-24:2020.

3.1.2

meter test unit

MTU

assembly of sources, frequency generator, reference or working standard, and error calculation and indication system to supply the required test signals to the DUT and to measure, calculate and display the error of the DUT

3.1.3

automatic meter test unit

AMTU

MTU which conducts, controls and monitors the desired function(s) or activity(ies) of meter testing through computer-controlled software

3.1.4

source

part of the MTU that generates test voltage signals and current signals with the appropriate frequency, magnitude, and with the appropriate phase angles between currents and voltages

Note 1 to entry: These test signals shall be independent from the mains input in the specified operating range.

Note 2 to entry: The test signals are based on the command(s) received from the test software or controller.

3.1.5

reference standard meter

reference standard

meter used to measure the unit of electrical energy and power

Note 1 to entry: The reference standard meter is designed and operated to obtain the highest accuracy and stability in a controlled laboratory environment.

Note 2 to entry: A reference standard meter shall be traceable to national or international primary standards.

3.1.6

working standard meter

working standard

meter used to measure the unit of electrical energy and power, for use in MTUs

Note 1 to entry: The working standard meter shall be calibrated against the reference standard (meter).

Note 2 to entry: An MTU can also be fitted with a reference standard used for day to day calibration of DUTs of high accuracy (reference standard used as the working standard).

3.1.7

standard meter

common term for the reference standard according to 3.1.5 or the working standard in accordance with 3.1.6

3.1.8

error calculation system

device or a group of devices to count pulses, or read energy values and to compare, calculate and indicate the relative error of the DUTs

Note 1 to entry: The default error calculation system receives pulses from the scanning heads or from the pulse outputs of the DUTs and compares these with pulses received from the standard meter.

3.1.9

output terminal

<of an MTU> terminal from which the test voltages and currents are applied to the DUTs

3.1.10

maximum output power of the source

output power corresponding to the highest load applied at the output terminals of a source

Note 1 to entry: It shall be expressed in VA and shall be defined separately for the test voltage and test current sources.

3.1.11

S

output stability of source

value or relative error of the output quantity of the source indicating that the output quantity may likely vary within this number when all other parameters such as supply voltage, etc., are in accordance with reference conditions (Annex B)

Note 1 to entry: The output stability (S) for voltage, current, power and frequency test output shall be separately defined in % and is given in Formula (1).

$$S = \frac{\max\{m_1(T), m_2(T), \dots, m_N(T)\} - \min\{m_1(T), m_2(T), \dots, m_N(T)\}}{\frac{1}{N} \cdot \sum_{k=1}^N m_k(T)} \cdot 100 \% \quad (1)$$

where:

S is the stability of the test output;

$m_N(T)$ is the N^{th} measured value with integration period T inside a successive sequence of measurements;

$m_k(T)$ is the k^{th} value, $k = 1 \dots N$ inside this sequence;

N is the number of values inside this sequence;

T is the integration period;

max is the largest value in a sequence of elements $\{m_1(T), m_2(T), \dots, m_N(T)\}$;

min is the smallest value in a sequence of elements $\{m_1(T), m_2(T), \dots, m_N(T)\}$.

The output stability (S_{abs}) of the phase angle between output values shall be separately defined in ° (degrees) and is given in Formula (2).

$$S_{\text{abs}} = \max\{m_1(T), m_2(T), \dots, m_N(T)\} - \min\{m_1(T), m_2(T), \dots, m_N(T)\} \quad (2)$$

Note 2 to entry: The purchaser and the manufacturer may mutually agree for the integration period T and the values N of the measuring sequence.

3.2 Definitions of active, reactive and apparent power

3.2.1

active power

active power at any single sinusoidal frequency component of a periodic signal in a single-phase circuit is defined as the product of the RMS values of current and voltage and the cosine of the phase angle between them, where the phase angle is the angle of the voltage signal vector with respect to the current signal vector

Note 1 to entry: Under sinusoidal conditions, the active power is the real part of the complex power.

Note 2 to entry: The active power of the periodic signal is the algebraic sum of the active power of the sinusoidal frequency components.

Note 3 to entry: The coherent SI unit for active power is the watt W.

Note 4 to entry: Time domain calculation under general conditions:

$$P = \frac{1}{T} \cdot \int_0^T u(t) \cdot i(t) \cdot dt \quad (3)$$

where:

- P is the active power;
- $u(t)$ is the instantaneous value of the voltage;
- $i(t)$ is the instantaneous value of the current;
- T is the integration time of the measurement cycle.

Fourier summation for frequency domain calculations with equal time periods for U and I up to n^{th} harmonic:

$$P = \sum_{k=1}^n U_k \cdot I_k \cdot \cos(\varphi_{uk} - \varphi_{ik}) = P_1 + P_2 + P_3 + \dots + P_n = P_1 + P_H \quad (4)$$

where:

- P_1 is the fundamental active power;
- P_H is the harmonic active power;
- U_k is the RMS value of the voltage component of order k ;
- I_k is the RMS value of the current component of order k ;
- φ_{uk} is the phase shift between the voltage component of order k and the fundamental voltage component;
- φ_{ik} is the phase shift between the current component of order k and the fundamental voltage component.

[SOURCE: IEC 62052-11:2020, 3.1.14, modified – Note 2 to entry has been replaced by a new Note 2 and Note 4 to entry has been added.]

3.2.2

apparent power

product of the RMS voltage U between the terminals of a two-terminal element or two-terminal circuit and the RMS electric current I in the element or circuit

Note 1 to entry: The coherent SI unit for apparent power is voltampere, VA.

Note 2 to entry: There are no IEC TC 13 standards available for meters measuring apparent power/energy.

Note 3 to entry: Time domain calculation under general conditions:

$$S = U \cdot I = \frac{1}{T} \cdot \sqrt{\int_0^T i^2(t) dt \cdot \int_0^T u^2(t) dt} \quad (5)$$

where:

- S is the apparent power;
- U is the RMS value of the voltage;
- I is the RMS value of the current;
- $u(t)$ is the instantaneous value of the voltage;
- $i(t)$ is the instantaneous value of the current;
- T is the integration time of the measurement cycle.

Note 4 to entry: Power triangle method to calculate the absolute value of apparent power for sinusoidal conditions.

$$S = \sqrt{P^2 + Q^2} \quad (6)$$

where:

S is the apparent power;

P is the active power;

Q is the reactive power.

Note 5 to entry: Fourier summation for frequency domain calculations with equal time periods for U and I up to n th harmonic:

$$S = U \cdot I = \sqrt{\sum_{k=1}^n U_k^2 \cdot \sum_{k=1}^n I_k^2} \quad (7)$$

where:

S is the apparent power;

U is the RMS value of the voltage;

I is the RMS value of the current;

U_k is the RMS value of the voltage component of order k ;

I_k is the RMS value of the current component of order k .

[SOURCE IEC 60050-131:2013, 131-11-41, modified – The original formula and Note 1 to entry have been omitted and Notes 3, 4 and 5 to entry have been added.]

3.2.3

reactive power

reactive power at any single sinusoidal frequency component of a periodic signal in a single-phase circuit is defined as the product of the RMS values of current and voltage and the sine of the phase angle between them, where the phase angle is the angle of the voltage signal vector with respect to the current signal vector

Note 1 to entry: In IEC TC 13 standards for reactive energy the reactive power and energy are defined for fundamental frequency only.

Note 2 to entry: The algorithm used for the calculation of reactive power is not specified, however the meter is expected to meet the requirements of the relevant accuracy class standard.

Note 3 to entry: The coherent SI unit for reactive power is voltampere, VA. The special unit var and its symbol var are also used.

Note 4 to entry: IEC 62053-24:2020 specifies reactive power / energy for fundamental components explicitly. Harmonics are considered as influence quantities. The algorithm is not specified, but the change of accuracy in the presence of harmonics shall be within the limits specified. To meet this requirement, meters need harmonic filtering. For testing it has to be verified, that also the standard meter measures the fundamental reactive power only in the presence of harmonics. This method is mandatory.

Note 5 to entry: Reactive power Q in a single-phase system for the fundamental frequency component of a periodic signal and defined as:

$$Q = U_1 \cdot I_1 \cdot \sin\varphi \quad (8)$$

where:

Q is the reactive power;

U_1 is the RMS value of the fundamental frequency components of the voltage;

I_1 is the RMS value of the fundamental frequency components of the current;

φ is the phase angle between U_1 and I_1 .

Note 6 to entry: The power triangle method is used to calculate the absolute value of total non-active power under general conditions. The definition in IEC 131-11-43 is widely known, used for the calculation of reactive.

The definition of "non-active power" is as follows for a two-terminal element or a two-terminal circuit under periodic conditions, quantity equal to the square root of the difference of the squares of the apparent power and the active power S and the active power P [IEV 131-11-43].

$$Q = \sqrt{S^2 - P^2} \quad (9)$$

where:

Q is the non-active power;
 S is the apparent power;
 P is the active power.

This method is unambiguous if only fundamental components are present. With sinusoidal voltages and non-sinusoidal currents the result includes the fundamental and distortion power. Prefixes of Q shall conform to IEC 60375. Standard meters determining accuracy according to IEC 62053-24:2020 do not use this method.

For sinusoidal conditions, the non-active power determined by the power triangle method is equal to the absolute value of the product of the apparent power and the sine of the phase angle.

Note 7 to entry: Time domain calculation on pure sinusoidal conditions (time phase method)::

$$Q = \frac{1}{T} \cdot \int_0^T u\left(t - \frac{T}{4}\right) \cdot i(t) \cdot dt \quad (10)$$

where:

Q is the reactive power;
 $u(t)$ is the instantaneous value of the voltage;
 $i(t)$ is the instantaneous value of the current;
 T is the time period of the fundamental component.

This method is only unambiguous under sinusoidal conditions with fundamental frequencies. In that case reactive power determined by the time displacement method is the product of the apparent power and the sine of the displacement angle. To realize this method, meters have a provision for phase shifting adjusted for the fundamental only. This method is not recommended.

Note 8 to entry: For unambiguous determination of errors the algorithm used by the standard meter for measuring Q and S shall be indicated in the test report of a DUT. This is particularly important when testing polyphase meters. In addition, the calculation method of how polyphase power is determined shall be indicated in the test report.

[SOURCE: IEC 62052-11:2020, 3.1.16, modified – Notes 4, 5, 6, 7, 8 to entry have been added.]

3.3 Definitions related to influence quantities

3.3.1

laboratory

<test and measurement area> area that is specifically used for analysis, testing and servicing, and places with equipment operated by trained personnel

Note 1 to entry: Guidelines for a laboratory setup are described in Annex E.

3.3.2

controlled laboratory environment

environment usually characterized by recognition and control of environmental phenomena and influences (especially through EMC) by users of the equipment in the laboratory

3.3.3

influence quantity

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

Note 1 to entry: This term is used in the "uncertainty" approach.

Note 2 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment.

Note 3 to entry: As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lie within the specified range.

[SOURCE: IEC 60050-311:2001, 311-06-01]

3.3.4

reference conditions

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

[SOURCE: IEC 60050-311:2001, 311-06-02, modified – to be better adapted to metering.]

3.3.5

variation of error

<due to an influence quantity> difference between the relative errors of the MTU when only one influence quantity assumes successively two specified values, one of them being the reference value

[SOURCE: IEC 62052-11:2020, 3.6.6, modified – the word "meter" replaced with "MTU" in the definition, and the note to entry omitted.]

3.3.6

reference temperature

ambient temperature specified for reference conditions

[SOURCE: IEC 62052-11:2020, 3.6.8]

3.3.7

rated operating conditions

set of specified measuring ranges for performance characteristics and specified operating ranges for influence quantities, within which the variations of operating errors of an MTU are specified and determined

[SOURCE: IEC 62052-11:2020, 3.6.10, modified – "a meter" replaced with "an MTU".]

3.4 Definitions related to accuracy

3.4.1

maximum permissible measurement error

extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

Note 1 to entry: Usually, the term "maximum permissible error" or "limits of error" is used where there are two extreme values.

Note 2 to entry: The term "tolerance" should not be used to designate "maximum permissible error".

[SOURCE: JCGM 200:2012, 4.26]

3.4.2

meter constant

number of revolutions of the rotor of an electromechanical meter or the number of pulses of a static meter at the test output, per energy unit

3.4.3**accuracy**

<general> closeness of agreement between a measured quantity value and a true quantity value of a measurand

[SOURCE: JCGM 200:2012, 2.13, modified – use of an admitted term "accuracy" rather than the preferred term "measurement accuracy", addition of the domain, and note to entry omitted.]

3.4.4**accuracy**

<of a reference or working standard> indicates the closeness of a measured quantity value in a given range of operation, at reference conditions and a true quantity value of a measurand

Note 1 to entry: The accuracy should be given for:

- a) accuracy of voltage measurements;
- b) accuracy of current measurements;
- c) accuracy of phase angle measurements;
- d) accuracy of frequency measurements;
- e) accuracy of active power / energy measurements;
- f) accuracy of reactive power / energy measurements;
- g) accuracy of apparent power / energy measurements.

3.4.5**accuracy**

<of a complete MTU> accuracy of the MTU considering the accuracy of the reference or working standard, the accuracy of the calculation system (if any), the accuracy of the test signals including the differences between the test positions

Note 1 to entry: Quantitative validations and qualifications should be done. The accuracy of the complete MTU may be close to the accuracy of the reference standard if:

- all differences between the accuracy of the working standard and the reference standard are considered in the calculations;
- the MTU is designed for testing a small number of meters at a time;
- the manufacturer made efforts to reduce the voltage differences between the terminals of the standard meter and the terminals of the DUTs;
- the manufacturer made efforts to compensate or minimize variations caused by the error calculation system.

Note 2 to entry: The manufacturer has to specify both kinds of accuracies: that of the working standard and that of the MTU.

3.5 Definitions related to testing**3.5.1****type test**

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

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

3.5.2**routine test**

conformity test made on each individual item during or after manufacture

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

3.5.3**acceptance test**

contractual test to prove to the purchaser that the item meets certain conditions of its specification

[SOURCE: IEC 60050-151:2001, 151-16-23, modified – the second preferred term "hand-over test" has been omitted.]

3.5.4

verification

<of calibration> set of operations which is used to check whether the indications, under specified conditions, correspond with a given set of known measurands within the limits of a predetermined calibration diagram

[SOURCE: IEC 60050-311:2001, 311-01-13, modified – Notes to entry have been omitted.]

3.5.5

commissioning test

test on an item carried out on site, to prove that it is correctly installed and can operate correctly

[SOURCE: IEC 60050-151:2001, 151-16-24]

3.5.6

maintenance test

test carried out periodically on an item to verify that its performance remains within specified limits, after having made certain adjustments, if necessary

[SOURCE: IEC 60050-151:2001, 151-16-25]

4 Meter test units and automated meter test units

Meter test units (MTUs) are assemblies of sources, reference or working standards, error calculation systems and indication systems to supply test parameters to and determine the error of the DUT.

Related to the quantity of meters to be measured the measuring procedures can be automated by automatic meter test units (AMTUs). These AMTUs are MTUs which conduct, control and monitor the desired function(s) of meter testing through computer-controlled software. These activities generally include the following minimum tasks:

- setting, generating, monitoring and controlling the test parameter(s), within defined limits and tolerances;
- carrying out the test automatically, measuring, calculating and indicating the error of the DUT;
- storing the results in a defined and reusable format.

The purchaser and the manufacturer may mutually agree for further automation such as connecting the meter and performing other activities automatically using agreed methods or techniques.

The AMTU generally includes the following components:

- sources;
- frequency generator;
- standard meter;
- scanning heads to detect the meter pulses or rotor marks;
- error calculation system;
- meter mounting fixtures;
- interface for data read outs of meter under test;
- software.

Instead of separate sources and standard meters, combined devices (calibrators) may be applied. Accuracy and environmental tests of both sources and standard meters are applicable for calibrators.

MSVTs (multi secondary voltage transformers) or ICTs (isolating current transformers) may be included additionally in the AMTU if more than one meter under test with permanent closed link is to be tested. Both transformer types are described and specified in Annex F and Annex G.

To determine the error of the meters under test, scanning heads may be replaced by register readings via interfaces of the AMTU if sufficient synchronism of the readings and/or sufficient register resolution in the DUT are achievable.

NOTE Data readout ports are part of agreements between manufacturer and user.

5 Meter accuracy test methods

5.1 General

The test methods described below can be used for all tests required for testing the DUTs. Modified or other test methods, which fulfil the same accuracy requirements, may be also applicable.

The test points and the required stability of the test signals shall be as specified in Clause 6. The required accuracy of the standard meter and the complete MTU shall be as specified in Table 17 and Table 19.

5.2 Energy comparison method

A method by which a known amount of energy is supplied both to the DUT and to the standard meter. This kind of test is also known as "dial test" or "register test" and is mainly used for register tests.

The relative error for energy comparisons is calculated as follows:

$$\delta W_{\text{dut}} = \frac{W_{\text{dut}} - W_{\text{st}}}{W_{\text{st}}} \cdot 100 \% \quad (11)$$

where:

δW_{dut} is the error of the DUT in %;

W_{dut} is the energy recorded by the DUT in [kWh] or [kvarh] or [kVAh];

W_{st} is the energy recorded by the standard meter in [kWh] or [kvarh] or [kVAh].

Measurement errors caused by switching ON/OFF the current source and by filter effects in the standard meter inputs can be minimized for example by choosing the measurement time appropriately.

If the error of the working standard meter in comparison to the reference standard meter (δW_{st}) needs to be considered in determining the total error of the DUTs, Formula (11) has to be adapted by an approximated term as follows:

$$\delta W_{\text{dut}} = \left[\frac{W_{\text{dut}}}{W_{\text{st}}} \left(1 + \frac{\delta W_{\text{st}}}{100\%} \right) - 1 \right] \cdot 100\% \quad (12)$$

where:

δW_{st} is the error of the working standard meter in % (taken from the calibration certificate).

5.3 Power–time measurement method (wattmeter method with register reading)

A method by which the energy supplied to the DUT(s) is determined by the product of a known constant power and a known interval of time.

The error is calculated as follows:

$$\delta W_{\text{dut}} = \frac{W_{\text{dut}} - P_{\text{st}} \cdot t}{P_{\text{st}} \cdot t} \cdot 100\% \quad (13)$$

where:

δW_{dut} is the error of the DUT in %

W_{dut} is the energy recorded by the DUT;

P_{st} is the power recorded by the standard meter;

t is the measuring time interval.

This method requires highly stable sources and accurate time controls.

The overall uncertainties due to the stability of power and time intervals have to be considered.

NOTE Due to the increased accuracy of electronic DUTs this method is seldom used.

The measuring time should guarantee at a minimum the progress of digits of the lowest register value (resolution), that is sufficient to prove the accuracy.

5.4 Pulse comparison method

For this method, pulses of an energy proportional pulse output of a standard meter are counted by a pulse counting device. The counter is started by a first pulse from the DUT and is stopped after completion of a given number of pulses from the DUT.

Pulses from electromechanical meters can be generated with help of a scanning head, based on sensing the rotor mark, or in the case of static meters, by a blinking LED or an electrical pulse output. A suitable pulse adapter is needed.

For counting the pulses delivered by the standard meter the following conditions shall be met: the test duration, at each test point, shall be selected so that the resolution error – determined by the number of pulses from the standard meter – shall be less than 1 % of the accuracy class of the DUT. If the manual or type approval of the DUT indicates a minimum test time, e.g. to fulfil the legal metrology requirements, that minimum test time shall be used.

The relative error of the DUT can be calculated from the nominal and actual number of pulses counted during the measurement period, as per Formula (14):

$$\delta W_{\text{dut}} = \frac{N_{\text{nom}} - N_{\text{act}}}{N_{\text{act}}} \cdot 100\% \quad (14)$$

where:

δW_{dut} is the error of the DUT in %;

N_{act} is the number of pulses actually received from the standard meter during the test;

N_{nom} is the number of pulses from the standard meter expected for the given measuring period.

$$N_{\text{nom}} = \frac{3\,600 \cdot 1\,000 \cdot N_{\text{dut}} \cdot f_{\text{nom}}}{m \cdot U_r \cdot I_r \cdot c_m} \quad (15)$$

where:

N_{dut} is the number of pulses (or revolutions) of the DUT;

f_{nom} is the power proportional frequency output of standard meter;

m is the number of phases;

U_r is the voltage range of the standard meter;

I_r is the current range of the standard meter;

c_m is the meter constant of the DUT in [1/kWh] or [1/kvarh] or [1/kVAh].

If the error of the working standard meter (δW_{st}) needs to be considered to determine the total error of the DUT, Formula (15) has to be adapted by an additional term as follows:

$$\delta W_{\text{dut}} = \left[\left(\frac{N_{\text{nom}} - N_{\text{act}}}{N_{\text{act}}} \right) + \left(\frac{N_{\text{nom}}}{N_{\text{act}}} \cdot \frac{\delta W_{\text{st}}}{100\%} \right) \right] \cdot 100\% \quad (16)$$

where:

δW_{dut} is the error of the DUT in %;

δW_{st} is the error of the working standard meter in % (taken from the calibration certificate).

6 Standard electrical values

6.1 Mains supply

The mains supply voltage shall be sufficiently stable to ensure a suitable accuracy of all components of the MTU necessary for testing meters of the given accuracy class. If necessary, supply voltage stabilizers shall be used. The requirements are shown in Table 1.

Table 1 – Mains power supply condition

Parameter	Value
Supply voltage U_n and mains condition	Shall be specified by the manufacturer
Variation in supply voltage	$0,85 U_n$ to $1,1 U_n$
Frequency f_n	50 Hz or 60 Hz
Frequency range	$f_n \pm 2 \%$
Power consumption	Shall be specified by the manufacturer
Neutral to ground voltage	$< 2 \text{ V}$
Voltage quality of mains supply	As specified in EN 50160

6.2 Output values and ranges of the test circuits

6.2.1 Test voltage circuit

The test voltage circuit may provide several voltage ranges to ensure suitable load conditions and accuracy. The requirements are shown in Table 2.

Table 2 – Test voltage circuit for each phase

Parameter	Value
Test circuit voltage range, U	30 V to 300 V (phase to neutral)
Setting resolution	0,1 V
Accuracy of the amplitude	$\pm 0,1 \%$ of the test value
Stability (S) of the amplitude	$< 100 \times 10^{-6}$ (with $T = 60 \text{ s}$, $N = 10$) $< 500 \times 10^{-6}$ (with $T = 5 \text{ s}$, $N = 24$)
Distortion factor at linear load	$< 0,5 \%$
Maximum permitted DC voltage	$< 0,2 \%$ of test voltage
Minimum output power per meter test position	15 VA RMS at the high end of the voltage range and at symmetrical loads with power factor in the range between 0,1 capacitive and 0,3 inductive
Protection	The output circuit shall be protected against short circuit and overload
The purchaser shall specify if the MTU shall be designed for single-phase or three-phase meter testing. The values given above shall be valid for each phase.	
The purchaser and the manufacturer may agree upon the suitable value for maximum voltage if different from 300 V and/or power ratings considering the peak current drawn by the power supply of DUTs. The same is valid for the voltage distortion factor for non-linear loads.	

6.2.2 Test current circuit

The test current circuit may provide several current ranges to ensure suitable load conditions and accuracy. The requirements are shown in Table 3.

Table 3 – Test current circuit for each phase

Parameter	Value
Test circuit current range I	1 mA to 120 A
Setting resolution	0,1 mA to 10 mA (depending on range)
Accuracy of amplitude of I	$\pm 1,0 \%$ ($1 \text{ mA} \leq I < 10 \text{ mA}$) $\pm 0,5 \%$ ($10 \text{ mA} \leq I < 50 \text{ mA}$) $\pm 0,1 \%$ ($50 \text{ mA} \leq I \leq 120 \text{ A}$)
Stability (S) of amplitude	$< 100 \times 10^{-6}$ (with $T = 60 \text{ s}$, $N = 10$) $< 500 \times 10^{-6}$ (with $T = 5 \text{ s}$, $N = 24$) for $I \geq 50 \text{ mA}$
Distortion factor at linear load	$< 0,5 \%$ ($I \geq 100 \text{ mA}$)
Maximum permitted DC current	$< 0,1 \%$ of test current
Minimum output power per meter test position	Minimum 30 VA RMS at the high end of the current range and at resistive loads
Protection	Output circuit shall be protected against open circuit and overload
The purchaser shall specify if the MTU shall be designed for single-phase meter testing or three-phase meter testing. The values given above shall be valid for each phase. The purchaser and the manufacturer shall agree on the suitable value for maximum current and/or power ratings, considering distance, connectivity and the use of isolating current transformers.	

6.2.3 Phase angle

The requirements for the phase angle are shown in Table 4.

Table 4 – Setting of phase angle between each phase voltage and current circuit

Parameter	Value
Range of phase angle	0° to 360°
Setting resolution	$0,01^\circ$
Stability (S_{abs}) of the angle setting	$0,05^\circ$ (with $T = 60 \text{ s}$, $N = 10$)
Accuracy of setting	$\pm 0,05^\circ$

6.2.4 Frequency

The requirements for the frequency generation are shown in Table 5.

Table 5 – Setting of frequency

Parameter	Value
Range of frequency	45 Hz to 65 Hz
Setting resolution	0,01 Hz
Stability (S) of the frequency setting	0,02 % (with $T = 60 \text{ s}$, $N = 10$)
Accuracy of setting	$\pm 0,02 \%$

6.2.5 Harmonics

The superimposition of harmonics shall be possible in the voltage and the current circuits. The requirements are shown in Table 6.

Table 6 – Setting of harmonics

Parameter	Value
Harmonic range	2 nd to 21 st
Amplitude of harmonics in percentage with respect to the fundamental frequency amplitude	0 % to 40 % for 2 nd to 5 th harmonic 0 % to 15 % for 6 th to 7 th harmonic 0 % to 10 % for 8 th to 21 st harmonic The peak value of the superimposed current or voltage may not exceed 1,4 $I_{\max}$ and 1,4 $U_{\max}$
Setting resolution	Maximum 1 % of fundamental frequency amplitude
Phase angle with respect to fundamental frequency	0° to ±180°
Accuracy of setting	Amplitude: 1 % Phase angle: 1° related to fundamental frequency
Generation of higher harmonics may be agreed between the purchaser and the manufacturer, e.g., the 40 th harmonic.	
NOTE $U_{\max}$ and $I_{\max}$ are the specified limits of voltage and current ranges of the MTU.	

The source should be capable of generating the test conditions as specified in 12.4.2.

6.3 Standard meter

6.3.1 Accuracy class

The accuracy of a standard meter should be at least 5 times better than the accuracy class of the DUT but minimum 0,1 %. The recommended accuracy classes for the standard meter are 0,02 %, 0,05 % and 0,1 %. Other accuracy classes can be agreed between the purchaser and the manufacturer.

6.3.2 Standard electrical values

The standard electrical values of standard meters are shown in Table 7.

Table 7 – Standard electrical values for the standard meter

Parameter	Standard value
Mains supply	U_n (as defined in 6.1)
Voltage measuring range	30 V to 300 V (phase to neutral) ¹⁾
Current measuring range	1 mA to 120 A ¹⁾
Frequency measuring range	45 Hz to 65 Hz
Minimum frequency bandwidth	Up to 1 260 Hz (21 st harmonic of 60 Hz) ¹⁾
Measurement mode for single-phase MTU	1 phase 2 wire active / reactive
Measurement modes for three-phase MTU	1 phase 2 wire active / reactive 3 phase 4 wire active / reactive and apparent 3 phase 3 wire active / reactive and apparent
Pulse output	The standard meter shall provide a power proportional pulse output for calibration and measuring purposes
Interface	The standard meter shall have interface(s) for communication and control
¹⁾ The maximum value of current, voltage and harmonics can be mutually agreed between purchaser and manufacturer.	

6.4 Magnetic field of the MTU

The magnetic induction produced by the MTU at the position of the DUTs and for the current and frequency ranges according to Table 7 shall not exceed the following values:

For $I \leq 10$ A $B \leq 0,002\ 5$ mT;

For $I > 10$ A $B \leq 0,000\ 25$ mT $\times (I/A)$

where:

I is the output current of the MTU in A;

B is the magnetic induction in air due to the magnetic field ($B = \mu_0 \times H$).

The test shall be performed without the DUT connected. The current circuits shall be short circuited.

6.5 Electrical and mechanical values for the scanning head(s)

The requirements for the scanning heads are shown in Table 8.

Table 8 – Electrical and mechanical values for the scanning head(s)

Parameter	Standard parameters
Receiver sensitivity	To sense the optical test output according to IEC 62052-11:2020, 5.8.2.2.
Distance to the LED of the DUT	> 10 mm ± 1 mm ¹⁾
Minimum impulse duration detection	100 μ s for sensing LEDs of static DUTs
Distance to rotor disk	Up to 45 mm
¹⁾ If the LED of the DUT radiates with the maximum strength specified in IEC 62052-11 (1 000 μ W / cm ²) the distance rises to 45 mm.	

6.6 Error calculation system

6.6.1 Functional requirements

The error calculation system receives pulses from the scanning head(s) or from the pulse outputs of the DUT(s) and compares those with pulses received from the standard meter. It shall be able to count the pulses and to calculate and indicate the relevant error of one or more DUTs.

This system shall have the following standard functions:

- the system shall indicate, for each DUT, the relative error along with the sign (+ or –);
- a reset function shall be available allowing to reset the error indication in the event that the error measurement is wrong for any reason;
- the system shall provide the parameters of the error calculation process for verification purposes.

Additional functionalities may be agreed between purchaser and manufacturer, e.g. an additional connector to connect a pulse output cable of an external reference standard meter for verification purposes.

6.6.2 Parameters

The requirements are shown in Table 9.

Table 9 – Parameters for the error calculation system

Parameter	Standard parameters
Pulse frequency range, which the system shall be able to count	0 kHz to 2,5 kHz
Resolution of error indication	Minimum 0,01 %
Elements of the error display	sign, digits and unit in %
Accuracy	±1 digit of the lowest digit

7 Constructional requirements of the MTU

7.1 General requirements

The MTU shall be of protective class I according to IEC 61140:2016. All parts which are subject to corrosion under normal working condition shall be protected effectively. Any protective coating shall not be liable to damage by ordinary handling nor to damage due to exposure to air under normal working conditions. The clearance and creepage distances shall be according to IEC 60664-1:2020, overvoltage category II, pollution degree 1.

The MTU shall be equipped with a mains switch, a mains fuse, and an emergency button.

7.2 Source and standard meter

The source and the standard meter may constitute a stand-alone unit or may be located in the meter mounting system. If they are permanently connected to the MTU, they shall have a protective conductor terminal.

7.3 Meter mounting system

7.3.1 General

The meter mounting system is a rack including the necessary constructional requisites and the connections, designed to allow meters to be tested under the test conditions specified in the relevant standards. The wiring layout and cross sections should be suitably selected in order to minimize voltage drop, power losses, magnetic induction and capacitive interference.

The meter mounting system shall be designed to accommodate the number of DUTs specified by the purchaser, together with the scanning heads, error calculation and display units, and, when required, multi secondary voltage transformers (MSVT) and/or isolating current transformers (ICT) for each DUT position.

The design of the test bench shall be agreed by the manufacturer and the purchaser.

7.3.2 Terminals

7.3.2.1 General

The purchaser and the manufacturer shall agree on the terminals at which the output values of the MTU are specified.

These terminals may be the terminals of the source or one of the DUT positions.

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

Electrical connections shall be designed to avoid contact pressure transmitted through flexible insulating material.

7.3.2.2 Test voltage output terminals

Each meter test position shall have voltage output terminals according to the number of phases. These terminals may be connected in parallel to the voltage source directly, or via MSVTs. MSVTs are specified in Annex F.

The terminals shall be equipped with sockets of 1 000 V, CAT III according to IEC 61010-031:2015, 6.5.2.1 to prevent a person from accidentally touching hazardous live parts.

The wiring shall ensure that the accuracy requirements and the reference test conditions are met at each meter test position.

Voltage cables supplied with the MTU shall be rated for the maximum test voltages.

7.3.2.3 Test current terminals

The meter mounting system shall have current input and output terminals according to the number of phases and test positions. These terminals may be connected in series to the current source directly, or via ICTs. ICTs are specified in Annex G.

The current terminals shall be able to carry the maximum test currents continuously, without forced cooling under the operating conditions specified. A limit on the duration of exposure may be agreed between the manufacturer and the purchaser.

The manufacturer and purchaser may agree on the connection method for example using free wiring between the DUT terminals or using quick connectors.

NOTE A quick connector is an assembly of prongs designed for the terminal block of the DUT. By means of a mechanical lifter all prongs contact the terminals of the terminal block simultaneously.

8 Information and marking requirements

8.1 General

NOTE This Clause 8 is based on the following references: IEC 62052-11:2020, Clause 6, IEC 62055-31:2005, 5.13; IEC 62052-31:2015, Clause 5, IEC 61010-1:2010, Clause 5, IEC 61010-1:2010/AMD1:2016, Clause 5, and IEC 62477-1:2022, Clause 6.

The purpose of this Clause 8 is to define the marking of the information necessary for the safe selection, installation and commissioning, use and maintenance of an MTU. The required information is presented in Table 10 showing where the information shall be provided, with reference to explanatory subclauses.

The requirements of this Clause 8 apply to the whole MTU component, unless otherwise stated. All information shall be in an appropriate language, and documents shall have identification references.

Table 10 – Information requirements

Information for selection	Subclause	Location ^{a, b}				Technical subclause
		C	IM	UM	MM	
<i>General information</i>	8.3.2					
Manufacturer's name or trade mark		x	x	x	x	-
Designation of function, and type		x	x	x	x	-
Space for approval mark (if any)		x	x	x	x	-
Place of manufacture		x				-
Serial number		x				-
Protective class			x		x	8.4.4
Environmental conditions, storage			x		x	9.1
Environmental conditions, operation			x		x	9.1
Reference temperature if different from 23 °C			x		x	9.1
Owner specified information						-
Reference to standards			x		x	-
Reference to instructions			x	x	x	-
Fuse ratings		x	x	x	x	-
Supply voltage, frequency, max. apparent power, number of phases		x	x	x	x	6.1
<i>For standard meters</i>	8.3.3					
Measuring voltage range		x	x	x	x	6.3.2
Measuring current range		x	x	x	x	6.3.2
Measuring frequency range		x	x	x	x	6.3.2
Number of phases, number of wires, service type(s)			x	x	x	6.3.2
Accuracy		x	x	x	x	6.3.1
<i>For sources</i>	8.3.4					
Voltage, current and power		x	x	x	x	6.2.1, 6.2.2, 6.2.3
Product specific markings		x	x	x	x	-

Information for selection	Subclause	Location ^{a, b}				Technical subclause
		C	IM	UM	MM	
<i>ICTs and MSVTs</i>	8.3.5					
Measuring range		x	x	x	x	F.4, G.4
Frequency range		x	x		x	F.4, G.4
Accuracy		x				F.4, G.4
Output power		x	x	x	x	F.4, G.4
<i>For the communication interfaces and error calculation systems</i>	8.3.6					
Product specific markings		x	x	x	x	-
Communication medium		x	x	x	x	-
<i>For installation and commissioning</i>	8.4					-
Dimensions and mass	8.4.2		x		x	-
Connection requirements	8.4.3		x			-
Connecting cables	8.4.3.2	x	x		x	-
Connection and wiring diagrams	8.4.3.3		x		x	-
Auxiliary terminals	8.4.3.4	x	x		x	-
Protection requirements	8.4.4					-
Protective class and earthing	8.4.4		x		x	-
Self-consumption	8.4.5		x		x	-
<i>For use</i>	8.5					-
General	8.5.1			x		-
Display, push buttons and other controls	8.5.2			x		-
Connection to other equipment	8.5.3			x		-
External protection devices	8.5.4			x		-
Cleaning	8.5.5					-
<i>For maintenance</i>	8.5.6				x	-
^a Location: C = Case. These markings may appear on nameplate(s) or may be carried by the unit cover(s) in a permanent manner; IM = Installation manual; UM = User's manual; MM = Maintenance manual. ^b The installation, user's and maintenance manuals may be combined as appropriate and, if acceptable to the purchaser, may be supplied in electronic format. When more than one of any product is supplied to a single purchaser, it is not necessary to supply a manual with each unit, if acceptable to the purchaser.						

8.2 Labels, signs and signals

Labelling shall be in accordance with good ergonomic principles so that notices, controls, indications, test facilities, etc. are sensibly placed and logically grouped to facilitate correct and unambiguous identification.

All safety related equipment labels should be placed in such a way that they will be readily visible to the intended viewer and alert the viewer to any hazard in time for the viewer to take appropriate action.

Graphic symbols shall be in accordance with IEC 60417, IEC 60617, ISO 7000, as appropriate. IEC 60417 and ISO 7000 symbols that may be used on metering equipment are shown in Annex A. Symbols not shown in these database standards shall be explained where used. There are no colour requirements for symbols.

The documentation of the MTU shall include a statement that it shall be consulted in all cases where symbol 14 of Table A.1 is marked, in order to find out the nature of the potential hazards and any actions which have to be taken to avoid them.

Safety signs shall comply with ISO 3864-1.

The signal words indicated hereinafter shall be used and the following hierarchy respected:

- **DANGER** to call attention to a high risk, for example: "High voltage";
- **WARNING** to call attention to a medium risk, for example: "This surface can be hot.";
- **CAUTION** to call attention to a low risk, for example; "Some of the tests specified in this standard involve the use of processes imposing risks for the operators and on persons concerned."

Danger, warning and caution markings on the metering equipment shall be prefixed with the word "DANGER", "WARNING", or "CAUTION" as appropriate in letters not less than 3,2 mm high. The remaining letters of such markings shall be not less than 1,6 mm high.

8.3 Information for selection

8.3.1 General

MTUs shall be provided with information relating to function, electrical characteristics and intended environment to determine the fitness of the MTU for the right purpose. This information includes, but is not limited to the following.

8.3.2 General information

For the MTU equipment, the following general information shall be provided:

- manufacturer's name or trade mark;
- designation of type, preferably in local language;
- approval mark or space for it, if requested by notified bodies;
- place of manufacture, if required;
- serial number;
- protective class;
- environmental conditions for storage and operation;
- reference temperature if different from 23 °C;
- owner-specified information, as agreed by the manufacturer and the purchaser;
- reference to instructions for installation, operation and maintenance.

8.3.3 Information related to standard meters

For standard meters, the following information shall be provided in accordance with the relevant product standards for the DUT (electricity meter):

- measuring voltage;
- measuring current;
- frequency range;

- service type. This implies:
 - the number of phases;
 - the number of wires for which the meter is suitable;
- quantities measured. This implies:
 - active energy;
 - reactive energy;
 - apparent energy;
 - voltage;
 - current;
 - frequency;
 - phase angle;
- measuring principle (according to 3.2);
- accuracy (related to the measured quantity).

8.3.4 Information related to sources, error calculation systems and frequency generators

The equipment includes frequency generators, error calculation systems and voltage and current sources. For voltage and current sources and frequency generators the following information shall be provided:

- the type and value of auxiliary supply voltage (AC or DC);
- the range of output values;
- the maximum power consumption.

For sources, the following additional information shall be provided:

- output specifications for voltage ranges in respect to frequency;
- output specifications for current ranges in respect to frequency.

For sources, the following information shall be suitably displayed:

- the active operating range;
- On/Off status;
- faults;
- the actual value of voltage, current and frequency.

8.3.5 Information related to the ICTs and MSVTs

For ICTs and MSVTs, the following information shall be provided:

- voltage range / max. load and accuracy for MSVTs;
- current range / max. load and accuracy for ICTs;
- frequency range.

8.3.6 For the communication interfaces and error calculation systems

For these devices, the following information shall be provided:

- communication channel;
- the relevant standard(s);
- operating voltage, if not specified in standards;

- status information, power consumption.

8.4 Information for installation and commissioning

8.4.1 General

Safe and reliable installation is the responsibility of the installer. The manufacturer of MTUs shall provide information to support this task. This information shall be unambiguous, and may be in diagrammatic form.

NOTE Since any electrical equipment can be installed or operated in such a manner that hazardous conditions can occur, compliance with the requirements of this document does not by itself assure a safe installation. However, when equipment complying with those requirements is properly selected and correctly installed, commissioned and used, the hazards will be minimized.

8.4.2 Dimensions and mass

The following information shall be provided by the manufacturer: dimensional drawing, layout drawing, mass.

The data may be additionally provided in more than one unit (for example in mm and in inches).

8.4.3 Connection

8.4.3.1 General

Information shall be provided to enable the installer to make safe electrical connections from the MTU to the supply network. This shall include information for protection against hazards.

8.4.3.2 Connecting cables

Generally, national regulations are in place concerning electrical installations. These regulations specify the type and size of the connection cables to be used.

The installation manual shall include a statement that the installer shall consult the local regulations. The installation manual shall contain recommendations for the type of connecting cables to be used. Recommended cable terminations and requirements for tightening torque values shall be specified as well where applicable.

8.4.3.3 Connection diagrams

Every MTU shall be provided with a diagram of connections. If the terminals are marked, this marking shall appear on the diagram.

8.4.3.4 Auxiliary terminals

Terminals and connectors of auxiliary circuits, other than those for measuring voltage and current, shall be readily identifiable by the equipment markings. The following information shall be provided in the documentation as far as relevant for safety and as applicable:

- the function(s): e.g. pulse input/output, control input/output;
- the kind of the circuit(s), e.g. optocoupler, relay, solid state relay;
- type of voltage (AC or DC), nominal, minimum and maximum voltages;
- nominal and maximum frequency, as applicable.

8.4.4 Protection – Protective class and earthing

MTUs may be connected to the mains via a plug or be permanently connected. As the equipment is of protective class I, a protective conductor shall be present.

The installation manual shall include a statement as to how the earth wire is or shall be connected.

8.4.5 Self-consumption

For the supply circuits of the MTU and for auxiliary circuits (without the supply of measuring voltage and measuring current outputs) the following information shall be provided in the instruction and user's and maintenance manuals: the maximum power consumption in watts (active power) or volt-amperes (apparent power), or the maximum rated input current, with all accessories or plug-in modules connected but without DUTs.

8.5 Information for use

8.5.1 General

The user's manual shall include all information regarding the safe operation of the MTU. In particular, it shall identify any hazardous materials and risks of electric shock, overheating, explosion, excessive acoustic noise, etc.

All safety marking shall be clearly explained.

The user's manual shall also indicate any hazards which can result from reasonably foreseeable misuse of the metering equipment, especially when working on the DUTs during power-on.

8.5.2 Display, push buttons and other controls

The user's manual shall provide a description of the main items that can be displayed on the MTU equipment.

8.5.3 Connection to user's equipment

If the connection of user's equipment is possible, the necessary connection diagrams, the identification, marking and description of the connectors, and the necessary operations shall be provided.

The user's manual shall also indicate any hazards, which can result from connecting user's equipment.

8.5.4 External protection devices

If external protection devices such as fuses and circuit breakers may be operated by the user, then any safety hazards related to their operation shall be explained in the user's manual of the MTU.

8.5.5 Cleaning

The user's manual shall provide information for cleaning if applicable.

8.6 Information for maintenance

Safety information shall include in the installation and maintenance manuals if applicable the following:

- preventive maintenance procedures and schedules;
- safety precautions during maintenance;
- location of live parts that can be accessible during maintenance (for example, when covers are removed);
- adjustment procedures;

- sub-assembly and component repair and replacement procedures;
- information on safe disposal of the equipment and any replaceable parts;
- verification of the safe state of the equipment after repair;
- any other relevant information.

9 Climatic conditions for the MTU

9.1 Normal environmental conditions

The MTU and its sub-assemblies shall be designed to operate under the following climatic conditions in Table 11.

Table 11 – Climatic conditions

Climatic conditions	
Nominal temperature	23 °C ± 2 °C
Climatic conditions for operation	3K2 ¹⁾
Climatic conditions for transport and storage	2K2 ²⁾
¹⁾ In accordance with IEC 60721-3-3: Low air temperature +15 °C, high air temperature +30 °C, low relative humidity 10 %, high relative humidity 75 %.	
²⁾ In accordance with IEC 60721-3-2: Low air temperature –25 °C, high air temperature +60 °C, high relative humidity 75 %. Storage and transport of the MTU at the extremes of this temperature range should only be for a maximum period of 6 h.	

9.2 Extreme environmental conditions

NOTE The following text is based on IEC 60721-3-3:2019, Clause 4.

Specifications for products to operate under extreme or special environmental conditions are a matter for negotiation between the manufacturer and the purchaser.

9.3 Temperature limits and resistance to heat

The temperature of easily touched surfaces shall not exceed the values given in Table 12 at the maximum temperature of the operating range.

Table 12 – Surface temperature limits

Part		Limit °C
1)	Outer surface of enclosure parts likely to be touched (approximately 1 s)	
	a) metal, uncoated or anodised	65
	b) metal, coated (paint, non-metallic)	75
	c) glass and ceramics	80
	d) plastics	85
2)	User operated devices	
	a) metal	55
	b) glass and ceramics	65
	c) plastics	70
NOTE The effect of the duration of contact is given in ISO 13732-1.		

10 Electrical requirements of the MTU

10.1 Influence of mains supply

The MTU and its components shall be designed to work under the mains supply conditions as described in EN 50160.

10.2 Insulation

10.2.1 General

The MTU and its incorporated components shall retain adequate dielectric qualities under normal conditions of use.

10.2.2 Clearances and creepage distances

Clearances and creepage distances shall comply with the requirements of IEC 61010-1:2010 and of IEC 61010-1:2010/AMD1:2016 for overvoltage category II and with the requirements of IEC 61010-031:2015 and of IEC 61010-031:2015/AMD1:2018 for measurement category II, if not otherwise specified.

10.2.3 Verification of clearances and creepage distances

10.2.3.1 Verification by measurement

Verification of clearances and creepage distances shall be performed as specified in IEC 60664-1:2020, 6.2.

10.2.3.2 Verification of clearances using impulse voltage tests

The clearances shall be verified by performing the impulse voltage tests as specified in IEC 60664-1:2020. These type test refers to each single component of an MTU.

10.2.4 AC voltage test

10.2.4.1 Test voltage

The test has to be performed in accordance with IEC 62052-31:2015, 6.10.2.5. The test voltage shall be substantially sinusoidal, having a frequency between 45 Hz and 65 Hz, and applied for 60 s. The power source shall be capable of supplying at least 500 VA.

The source voltage shall be verified with an accuracy of better than 3 %.

The voltage shall be applied to the test object starting at a value sufficiently low to prevent any effect of overvoltages due to switching transients. It shall be maintained for the specified time and then rapidly decreased, but not suddenly interrupted as this may generate switching transients which could cause damage or erratic test results.

10.2.4.2 Performing the tests

The test voltages and the points of application are specified in Table 13.

Each component of the MTU shall be treated and tested as a DUT:

- voltage source and current source;
- standard meter;
- meter test rack.

The tests are carried out during the manufacturing of a newly manufactured meter test unit.

Table 13 – AC voltage tests

	Test voltage kV Protective class I	Point of application of test voltage
Meter test rack	2	Between, on the one hand, all current and voltage circuits as well as all other circuits whose reference voltage is above 33 V, connected together, and, on the other hand, earth.
Source	2	Between, on the one hand, any circuit whose reference voltage is above 33 V and, on the other hand, all other independent circuits whose reference voltage is above 33 V connected together.
Standard meter	2	Between circuits not intended to be connected together in service.
Equipment with mains supply	2	

During these tests no flashover, disruptive discharge or puncture shall occur.

11 Electromagnetic compatibility

11.1 General requirements and performance criteria

The MTU shall be designed in such a way that conducted or radiated electromagnetic phenomena and electrostatic discharge neither damage nor subsequently influence the function and the accuracy of the MTU. The MTU shall meet the requirements for light industrial locations. However, RF transmitters such as mobile telephones shall not be used in close proximity of the MTU.

The phenomena and test levels shall be as specified in IEC 61326-1:2020, Table 1, unless otherwise specified in the following subclauses.

Short duration electromagnetic phenomena are considered as disturbance and the performance criteria specified in IEC 61326-1:2020, Table 1 apply. Continuous and long duration electromagnetic phenomena are considered as influence quantities and the accuracy requirements for the standard meter are specified in Table 14.

For these tests, the test points for sources, MSVTs, ICTs and standard meters shall be:

- $I_n = 5 \text{ A}$;
- $U_n = 120 \text{ V}$;
- $f_n = 50 \text{ Hz}$;
- all power circuits energized with reference voltage (where applicable);
- balanced voltage and current;
- power factor $\cos \varphi = 1$ and $\sin \varphi = 1$.

This test point should be preferably used even though the tested equipment has several current, voltage or frequency ranges.

Table 14 – Limits of variation of error of standard meters during immunity test

Phenomenon	Accuracy class of the standard meter used in the MTU		
	0,02	0,05	0,1
Electromagnetic RF fields	0,02	0,05	0,1
Conducted RF	0,02	0,05	0,1
Power frequency magnetic field test	0,02	0,05	0,1

The definition of performance criteria is in line with the definition in IEC 61326-1:2020, 6.4. The primary functions are the energy registration and the error calculation.

11.2 General test conditions

11.2.1 General

If the EMC tests cannot be performed on the complete MTU, each component shall be treated and tested separately as a DUT.

Unless otherwise specified or applicable, the components of the MTU shall be tested as table-top equipment, in their normal working position and operating condition. Complete MTUs can be tested as floor standing equipment. All parts intended to be earthed shall be earthed.

11.2.2 Test of immunity to electrostatic discharges

The discharges shall be applied to the enclosure port of the voltage source and current source, the standard meter, the MSVT, the ICTs and the error calculation system.

The test level shall correspond to IEC 61326-1:2020 for industrial locations and industrial electromagnetic environment.

Performance criterion B.

11.2.3 Test of immunity of electromagnetic RF Fields

This test applies to the enclosure port of the voltage source and current source, the standard meter, the MSVT, the ICTs and the error calculation system. The cable length exposed to the field shall be 1 m.

a) Test of standard meter:

- device in operating condition;
- test points as specified in 11.1;
- limits of variation of error as specified in Table 14.

b) Test of voltage source and current source:

- device in operating condition;
- test points as specified in 11.1;
- limits as specified in Table 2 and Table 3.

c) Test of MSVT and ICTs:

- device in operating condition;
- test points as specified in 11.1;
- limits as specified in Table F.1 and Table G.2.

Performance criterion A.

11.2.4 Immunity to power frequency magnetic fields of external origin

The test level shall correspond to IEC 61326-1:2020, Table 2, industrial locations and industrial electromagnetic environment, but with 400 A/m, using the immersion method.

a) Test of standard meter:

- device in operating condition;
- test points as specified in 11.1;
- limits of variation of error as specified in Table 14.

b) Test of voltage source and current source:

- device in operating condition;
- test points as specified in 11.1;
- limits as specified in Table 2 and Table 3.

c) Test of MSVT and ICTs:

- device in operating condition;
- test points as specified in 11.1;
- limits as specified in Table F.2 and Table G.2.

Performance criterion A.

11.2.5 Test of immunity to fast transient bursts

The test voltage shall be applied to the AC power ports of the voltage source and current source, the MSVT, ICTs, the standard meter and frequency generators:

- a) between the terminals of each circuit normally connected to the mains;
- b) between any two independent circuits having reference voltages over 40 V;
- c) between each independent circuit having reference voltage over 40 V and earth.

The test level shall correspond to IEC 61326-1:2020, Table 2, industrial locations.

Duration of the test: 60 s at each polarity.

Performance criterion B.

11.2.6 Test of immunity to surges

The surges shall be applied to the AC power ports of the voltage and current sources, the MSVT, ICTs and the standard meter.

The test level shall correspond to IEC 61326-1:2020, Table 2, industrial locations, and industrial electromagnetic environment.

Performance criterion B.

11.2.7 Test of immunity to conducted disturbances, induced by RF (radio frequency) fields

The test voltage shall be applied line-to-line to the AC power ports of the voltage and current sources, the MSVT, ICTs and the standard meter.

The test level shall correspond to IEC 61326-1:2020, Table 2, industrial locations.

a) Test of standard meter:

- device in operating condition;
 - Test points as specified in 11.1;
 - device in operating condition;
 - Limits of variation of error as specified in Table 14.
- b) Test of voltage source and current source:
- device in operating condition;
 - Test points as specified in 11.1;
 - Limits as specified in Table 2 and Table 3.
- c) Test of MSVT and ICTs:
- device in operating condition;
 - test points as specified in 11.1;
 - limits as specified in Table F.2 and Table G.2.

Performance criterion A.

11.2.8 Radio interference suppression

The test shall be carried out on the complete MTU or on the individual components of the standard meter, and also on the voltage source and current source, MSVT and ICTS of the MTU in accordance with CISPR 11.

The standard meter shall be in normal operating condition without DUTs connected:

- device in operating condition.

The voltage source and current source shall be in normal operating condition:

- power circuits energized with reference voltage;
- loaded with 50 % of the maximum output power of the sources, at resistive load.

The test result shall comply with the requirements given in CISPR 11:2015, CISPR 11:2015/AMD1:2016, and in CISPR 11:2015/AMD2:2019 for Class A Group 1 equipment.

12 Standard meter

12.1 General

The tests in 12.3 and 12.4 are applicable for type testing.

12.2 Accuracy requirements under reference conditions

When the standard meter is under the reference conditions given in Annex B the relative errors shall not exceed the limits for the relevant accuracy class given in Table 15. If the standard meter is designed for the measurement of energy in both directions, the values shall apply for both directions.

The values given in Table 15 apply to standard meters with voltage range 30 V to 300 V, current range 1 mA to 120 A and frequency range 45 Hz to 65 Hz. Other ranges may be agreed between the manufacturer and the purchaser.

Table 15 – Relative error limits for the standard meter

Quantity measured	Range	Relative error limits for accuracy class (in percentage of the true value) ¹⁾		
		0,02	0,05	0,1
Voltage	30 V to 300 V	±0,02	±0,05	±0,1
Current	1 mA ≤ I < 10 mA	±0,08	±0,2	±0,4
	10 mA ≤ I < 50 mA	±0,04	±0,1	±0,2
	50 mA ≤ I ≤ 120 A	±0,02	±0,05	±0,1
		Relative error limits for accuracy class (in percentage of the true value of apparent energy / power) ²⁾		
Active, reactive and apparent power / energy in the complete voltage range	1 mA ≤ I < 10 mA	±0,08	±0,2	±0,4
	10 mA ≤ I < 50 mA	±0,04	±0,1	±0,2
	50 mA ≤ I < 120 A	±0,02	±0,05	±0,1
		Limits of drift per year for accuracy class (in percentage of the true value) ³⁾		
Voltage	30 V to 300 V	±0,005	±0,01	±0,025
Current	50 mA to 120 A	±0,005	±0,01	±0,025
Active, reactive and apparent power	30 V to 300 V 50 mA to 120 A	±0,01	±0,025	±0,05
¹⁾ The accuracy of the voltage measurement must be maintained in every current range. The accuracy of the current measurement must also be maintained in every voltage range. ²⁾ The relative error limits for active and reactive power or energy are related to power factor 1. The relative error limits for power factors different from 1 arise from the relative error limits at 1 divided by the corresponding power factor according to the example below. ³⁾ For uncertainty calculations it is feasible to take the drift of voltage, current and power measurement accuracy from the manufacturer's type specification.				
Example: Calculation of error limits for active and reactive power measurement at power factors $\cos \varphi = 0,5$ or $\sin \varphi = 0,866$ and relative error limit for apparent energy measurement of ±0,05 %. The relative error limit of active power measurement is equal to ±0,05 % / 0,5 = ±0,1 %. The relative error limit of reactive power measurement is equal to ±0,05 % / 0,866 = ±0,057 7 %.				

The error limits shall remain the same in the case when a three-phase standard meter measures single-phase current but with balanced polyphase voltage applied to the voltage circuits. The difference between the relative error when the standard meter is carrying a single-phase load and a balanced polyphase load at unity power factor shall not exceed 0,02 %, 0,05 % and 0,1 % for standard meter of classes 0,02, 0,05 and 0,1, respectively.

12.3 Limits of error due to influence quantities

The additional relative error due to the change of influence quantities with respect to reference conditions, as given in Annex B shall not exceed the limits for the relevant accuracy class given in Table 16.

The values given in Table 16 apply to reference standard meters with voltage range 30 V to 300 V and current range 1 mA to 120 A and frequency range 45 Hz to 65 Hz. Other ranges may be agreed between the manufacturer and the purchaser.

Table 16 – Influence quantities

Influence quantity	Range ¹⁾	$\cos \varphi / \sin \varphi$	Mean temperature coefficient in 1/K for accuracy class		
			0,02	0,05	0,1
Ambient temperature variation (+15 °C to +35 °C)					
Voltage measurement	30 V to 300 V	NA	15×10^{-6}	30×10^{-6}	60×10^{-6}
Current measurement	50 mA to 120 A	NA	15×10^{-6}	30×10^{-6}	60×10^{-6}
Active, reactive and apparent power / energy measurement	30 V to 300 V 50 mA to 120 A	1	25×10^{-6}	50×10^{-6}	80×10^{-6}
NOTE The effect of the following influence quantities applies to the measurement of active, reactive and apparent power / energy only.			Limits of variation of the relative error for standard meter of accuracy class		
Influence quantity	Range ¹⁾	$\cos \varphi / \sin \varphi$	0,02	0,05	0,1
Reversed phase sequence	30 V to 300 V 50 mA to 120 A	1	$\pm 0,01$	$\pm 0,02$	$\pm 0,05$
Harmonic components in voltage and current circuit ²⁾	$U_1 = 30 \text{ V to } 300 \text{ V}$ $I_1 = 50 \text{ mA to } 120 \text{ A}$	1	$\pm 0,04$	$\pm 0,1$	$\pm 0,2$
Odd harmonics in the AC current circuit ³⁾	$I_1 = 50 \text{ mA to } 120 \text{ A}$	1	$\pm 0,04$	$\pm 0,1$	$\pm 0,2$
Sub-harmonics in the AC current circuit	$I_1 = 50 \text{ mA to } 120 \text{ A}$	1	$\pm 0,04$	$\pm 0,1$	$\pm 0,2$
Magnetic induction of external origin 0,5mT ⁴⁾	30 V to 300 V 50 mA to 120 A	1	$\pm 0,04$	$\pm 0,1$	$\pm 0,2$
Change in auxiliary supply voltage $\pm 10 \%$	30 V to 300 V 50 mA to 120 A	1	$\pm 0,04$	$\pm 0,1$	$\pm 0,2$
Change in auxiliary supply frequency $\pm 5 \%$	30 V to 300 V 50 mA to 120 A	1	$\pm 0,02$	$\pm 0,04$	$\pm 0,1$
¹⁾ The manufacturer can choose the test point which represents the entire range/spectrum. ²⁾ The test condition shall be according to 12.4.1. ³⁾ The test condition shall be according to 12.4.2. ⁴⁾ A magnetic induction of external origin of 0,5 mT produced by a current of the same frequency as that of the voltage applied to the standard meter and under the most unfavourable conditions of phase and direction shall not cause a variation in the relative error of the standard meter exceeding the values shown in this table. This test shall be applied to the standard meter's enclosure port. The inductive coil as per 6.3.3 a) of IEC 61000-4-8:2009; immersion test method, continuous magnetic field applied in three perpendicular planes, field strength 0,5 mT (400 A/m). After the test position of the standard meter has been determined, the test duration shall be 1 min.					
In addition, the influence quantities and limits of variation of Table 14 are applicable.					

12.4 Accuracy tests in the presence of harmonics

12.4.1 Test with 5th harmonic in the current and voltage

Test conditions:

- fundamental frequency current: $I_1 = 5 \text{ A}$;
- fundamental frequency voltage: $U_1 = 230 \text{ V}$;
- fundamental frequency power factor: $\cos \varphi_1 = 1$ or $\sin \varphi_1 = 1$;
- content of 5th harmonic voltage: $U_5 = 10 \%$ of U_1 ;
- content of 5th harmonic current: $I_5 = 40 \%$ of I_1 ;
- harmonic power factor: $\cos \varphi_5 = 1$ or $\sin \varphi_5 = 1$;
- fundamental and harmonic voltages are in phase, at positive zero crossing.

The variation of the relative error when the MUT is subjected to the test condition shall not exceed the limits of variation given in Table 16.

12.4.2 Tests of the influence of odd and sub-harmonics

The tests of the influence of odd and sub-harmonics shall be made with the circuit shown in Figure C.1 or with other equipment able to generate the required waveforms, and the current waveforms as shown in Figure C.2 and Figure C.4 respectively.

The variation of the relative error when the meter is subjected to the test waveform given in Figure C.2 and Figure C.4 respectively and when it is subjected to the reference waveform shall not exceed the limits of variation given in Table 16.

The values in the figures were given as an example for 50 Hz. For other frequencies the values may be adapted accordingly.

13 Software requirements

13.1 Application

These requirements apply to the software supplied with the MTU and include applications including meter calibration and certification of newly manufactured meters using 100 % inspection or sampling inspection, as well as validation, re-calibration and re-certification of meters already in use.

The manufacturer and the purchaser may agree on different requirements for the software if needed.

13.2 Identification

The software shall be clearly identifiable by the program name, version number, checksum or digital signature, target operating system as applicable.

13.3 Protection

The software and the test programs written by the operator(s) shall be protected against unauthorized modification and/or use. The administrator of the software may assign specific rights to each operator. Each entry of a program module shall only be possible with an identification of the operator at least by a password before use.

Measurement data shall be protected against unauthorized access.

13.4 Functional requirements

The software shall support the following functions as agreed between the manufacturer and the purchaser:

- Generation and storage of test programs: the program shall allow generating and storing test programs, with proper identifiers. It shall be possible to adapt the programs to different meter types, nominal values and ranges of current and voltage, and test purposes such as type test, calibration, sampling inspection, initial verification, etc. It shall be possible to verify and approve such programs by legal metrology bodies;
- Error compensation: the program shall allow, as agreed and authorized by legal metrology bodies, the compensation of the errors of the MTU and its components (standard meters, MSVTs, ICTs);
- Execution of test programs:
 - the program shall allow automatic or step-by-step execution of test programs;
 - it shall control, display and log the test parameters, such as connection mode, voltages, currents, frequency, phase angles, power factor, power, energy;
 - the program shall be able to send defined data and commands to the meter, as well as to receive and safely store data from the meter using the communication protocol and security features specified;
 - it shall also allow to give instructions to the operator and accept commands and parameters from duly authorized operators at specified points during the execution of the program;
 - the program shall monitor the operation of the MTU during execution of the program and if parameters are outside acceptable limits, give a warning sign or alarm and/or abort the program as appropriate;
 - the program shall provide information on its status, for example "Initialisation", "Measurement running", "Waiting for input from operator", "Aborted", "Finished", etc.
- Evaluation, presentation and archiving results: the program shall automatically calculate the errors; evaluate the results of the tests for each test points, for each meter position, and for defined meter lots. It shall display and print the results and store them safely and with proper identifiers for further processing.

Some of these aspects are further explained and detailed in the following subclauses.

13.5 Control and supervision of the MTU by the software

The software shall perform hardware supervision. Any malfunctions and faults of hardware components shall be detected in order to prevent incorrect meter calibrations or test results.

All data received from the measuring hardware shall be checked for plausibility and consistency. A warning or hint message shall be given to the operator in case of implausible or inconsistent results.

If some measurements cannot be completed, this shall not lead to program interruptions or malfunctions as far as this is feasible. Incomplete measurements shall not be evaluated, or if they are evaluated, then they shall be marked unambiguously. They shall not affect the presentation and storage of the results of other measurements, or if those measurements are affected in any way, they shall be marked unambiguously.

13.6 Creation, protection and storage of test programs

All test programs and parameter sets used for legal metrology purposes shall be easily understandable, properly documented, identifiable, adequately protected against inadmissible changes and safely stored on suitable storage media (paper or electronic data storage devices). Any changes shall be properly documented and, when necessary, approved by the responsible authority. The documentation shall include data such as name of the operator, time and date, reason for and list of changes, version, etc.

Parameter sets used for legally relevant purposes shall be stored with or unambiguously linked to the test protocols and may not be changed afterwards.

NOTE These requirements are verifiable by the local certification bodies and depend on the code of practice.

13.7 Protection and storage of test results and test protocols

Measured values, test results and related parameters shall be printed or stored as needed in suitable formats. It shall be always possible to correlate the test results to the test program generating those results and its parameters such as test sequence, test points, operator inputs, meter constants, error limits, pass/fail criteria, etc.

The test protocols shall be stored for each batch tested. They shall be easily identifiable, they shall be protected against any changes and it shall not be possible to erase them without prior approval by the responsible authority.

NOTE These requirements are verifiable by the local certification bodies and depend on the code of practice.

13.8 Documentation of the software

The software of the MTU shall be properly documented and accompanied with operating instructions delivered on a suitable storage media (paper or digital data storage devices). Software documentation shall be written in clear and unequivocal terms and in consistent form.

The software documentation shall at least include:

- the program name;
- the software version, release and operating system;
- the author of the program;
- contact details of the organization / person providing support;
- explanation of all functions and operator commands;
- description of test sequences;
- description of parameter tables;
- description of all calculation formulae used for calculating the results;
- list of error messages, diagnostic information and hints for troubleshooting;
- description of all display screens, printout and storage formats.

13.9 Software logs

The user shall maintain a logbook.

When the software is installed on a given hardware and under a given operating system, or when any changes are made, the following information shall be logged:

- date and time of installation or modification;
- name of operator having installed or modified the software;
- program name and version;

- identifiers of the relevant elements of the hardware controlled by the software;
- list of changes;
- documentation of how the changes influence the results;
- date and time of authorizing the use of the software by the responsible authority.

It shall be possible to prevent the use of the software or any modifications for legally relevant purposes until its use has been authorized by the responsible authority.

NOTE These requirements are verifiable by the local certification bodies and depend on the code of practice.

14 Accuracy requirements and tests

14.1 General

This Clause 14 specifies the overall accuracy requirements for the MTU, describes the various tests to be performed, the test points, test methods and the evaluation of the results.

NOTE Error definitions and error determination are given in Annex D.

14.2 Test methods for determination of the MTU accuracy

The determination of the overall error of a MTU shall be made according to either of the following methods:

Method 1 Comparison is done by comparing the energy delivered and indicated by the MTU working standard meter with the energy indicated by the reference standard meter according to the methods in 5.2 and 5.3 or comparable methods.

Method 2 The energy comparison can be done by comparing the number of pulses from a test output of the MTU working standard against the number of pulses from the test output of the reference standard meter according to the method in 5.4.

To measure the overall error of the MTU, the following conditions shall be fulfilled.

- a) Voltage terminals and current terminals of the reference standard meter shall be connected to the output terminals at one preferred location of the MTU where there is no DUT ;
- b) the MTU shall operate under reference conditions performing an accuracy test on a DUT. The reference standard meter shall be connected at the preferred output terminals of the meter test rack as the DUT. The determined errors are errors of the MTU;
- c) the MTU and the reference standard meter shall reach thermal stability;
- d) the recommended accuracy class of the reference standard meter used for testing of overall accuracy of the MTU is given in Table 17. If the calibration error of the reference standard meter is known, a required error correction can be applied;
- e) the tests are performed under reference conditions given in Table B.1;
- f) the MTU should have suitable hardware and software provisions to determine the overall error of the MTU. Error results should be stored for corrections of the error of the standard meter.

Table 17 – Recommended accuracy class of reference standard meter

	Accuracy class of the working standard meter used in the MTU		
	0,02	0,05	0,1
Recommended accuracy class of reference standard meter	0,01	0,01	0,02
For class 0,02 working standards, the calibration values in the test report of the reference meter may be used for proper corrections of the measuring error.			

14.3 Test points – Selection of voltage and current ranges

From all value combinations related to voltage, current, power factor and measuring mode the most significant ones for practice should be tested. The values given in Table 18 are recommended test points and can be separately agreed upon between the manufacturer and the purchaser.

Table 18 – Basic measurement table (recommended test points)

Measurement mode	Voltage V	Current A	$\cos \varphi / \sin \varphi$	Load of the MTU			
				Phase1	Phase 2	Phase 3	All phases
3 phase 4 wire active	30	0,05	1				X
3 phase 4 wire active	230	120	1 0,5 inductive 0,5 capacitive	X	X	X	X
		50		X	X	X	X
		20		X	X	X	X
		10		X	X	X	X
		5		X	X	X	X
		2		X	X	X	X
		1		X	X	X	X
		0,5		X	X	X	X
		0,1		X	X	X	X
		0,05		X	X	X	X
		0,02		X	X	X	X
		0,01	1	X	X	X	X
3 phase 4 wire reactive	230	5	1	X	X	X	X
			0,5 inductive	X	X	X	X
			0,5 capacitive	X	X	X	X
3 phase 3 wire active	60	5	1				X
3 phase 3 wire reactive	60	5	1				X
Tests may be carried out at one frequency between 50 Hz and 60 Hz if it is ensured that influence due to frequency is not significant.							
For single-phase MTUs only the test points of one phase are valid.							
For $I_{\max} > 120$ A an additional test point at $I_{\max}$ has to be added.							
The measurements for newly manufactured MTUs can be reduced for the test points already given in the calibration certificate of the standard meter supplied.							