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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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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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CONTENTS

FOREWORD 7
1 Scope 9
2 Normative references 9
3 Terms and definitions 10
3.1 Definitions related to the elements of the MTU 11
3.2 Definitions of active, reactive and apparent power 12
3.3 Definitions related to influence quantities 15
3.4 Definitions related to accuracy 16
3.5 Definitions related to testing 17
4 Meter test units and automated meter test units 18
5 Meter accuracy test methods 19
5.1 General 19
5.2 Energy comparison method 19
5.3 Power–time measurement method (wattmeter method with register reading) 20
5.4 Pulse comparison method 20
6 Standard electrical values 21
6.1 Mains supply 21
6.2 Output values and ranges of the test circuits 22
6.2.1 Test voltage circuit 22
6.2.2 Test current circuit 22
6.2.3 Phase angle 23
6.2.4 Frequency 23
6.2.5 Harmonics 24
6.3 Standard meter 24
6.3.1 Accuracy class 24
6.3.2 Standard electrical values 24
6.4 Magnetic field of the MTU 25
6.5 Electrical and mechanical values for the scanning head(s) 25
6.6 Error calculation system 26
6.6.1 Functional requirements 26
6.6.2 Parameters 26
7 Constructional requirements of the MTU 26
7.1 General requirements 26
7.2 Source and standard meter 26
7.3 Meter mounting system 27
7.3.1 General 27
7.3.2 Terminals 27
8 Information and marking requirements 28
8.1 General 28
8.2 Labels, signs and signals 29
8.3 Information for selection 30
8.3.1 General 30
8.3.2 General information 30
8.3.3 Information related to standard meters 30
8.3.4 Information related to sources, error calculation systems and frequency generators 31

8.3.5 Information related to the ICTs and MSVTs 31
8.3.6 For the communication interfaces and error calculation systems 31
8.4 Information for installation and commissioning 32
8.4.1 General 32
8.4.2 Dimensions and mass 32
8.4.3 Connection 32
8.4.4 Protection – Protective class and earthing 32
8.4.5 Self-consumption 33
8.5 Information for use 33
8.5.1 General 33
8.5.2 Display, push buttons and other controls 33
8.5.3 Connection to user's equipment 33
8.5.4 External protection devices 33
8.5.5 Cleaning 33
8.5.6 Information for maintenance 33
9 Climatic conditions for the MTU 34
9.1 Normal environmental conditions 34
9.2 Extreme environmental conditions 34
9.3 Temperature limits and resistance to heat 34
10 Electrical requirements of the MTU 35
10.1 Influence of mains supply 35
10.2 Insulation 35
10.2.1 General 35
10.2.2 Clearances and creepage distances 35
10.2.3 Verification of clearances and creepage distances 35
10.2.4 AC voltage test 35
11 Electromagnetic compatibility 36
11.1 General requirements and performance criteria 36
11.2 General test conditions 37
11.2.1 General 37
11.2.2 Test of immunity to electrostatic discharges 37
11.2.3 Test of immunity of electromagnetic RF Fields 37
11.2.4 Immunity to power frequency magnetic fields of external origin 38
11.2.5 Test of immunity to fast transient bursts 38
11.2.6 Test of immunity to surges 38
11.2.7 Test of immunity to conducted disturbances, induced by RF (radio frequency) fields 38
11.2.8 Radio interference suppression 39
12 Standard meter 39
12.1 General 39
12.2 Accuracy requirements under reference conditions 39
12.3 Limits of error due to influence quantities 40
12.4 Accuracy tests in the presence of harmonics 42
12.4.1 Test with 5^{th} harmonic in the current and voltage 42
12.4.2 Tests of the influence of odd and sub-harmonics 42
13 Software requirements 42
13.1 Application 42
13.2 Identification 42

13.3 Protection 42
13.4 Functional requirements 43
13.5 Control and supervision of the MTU by the software 43
13.6 Creation, protection and storage of test programs 44
13.7 Protection and storage of test results and test protocols 44
13.8 Documentation of the software 44
13.9 Software logs 44
14 Accuracy requirements and tests 45
14.1 General 45
14.2 Test methods for determination of the MTU accuracy 45
14.3 Test points – Selection of voltage and current ranges 46
14.4 Accuracy requirements 47
14.4.1 Limits of maximum permissible error 47
14.4.2 Correction of the error δW of the MTU 47
14.4.3 Mean value and repeatability of the measurements 48
14.5 Check of measurement results of the MTU 49
14.5.1 Basic measurements of the MTU 49
14.5.2 Maintenance measurement of the MTU 49
14.6 Tests and testing procedures 49
14.6.1 Type tests 49
14.6.2 Routine tests 49
14.6.3 Acceptance test 51
14.6.4 Commissioning test 51
Annex A (informative) Symbols according to IEC 60417 52
Annex B (normative) Reference conditions 53
Annex C (informative) Test circuits and test signals for testing in the presence of harmonics 54
C.1 General 54
C.2 Phase fired control (odd harmonics) 54
C.3 Burst control (sub-harmonics) 56
Annex D (informative) Calculation of errors and the associated expanded measurement uncertainty 58
D.1 General 58
D.2 Degrees of freedom and sensitivity coefficient 58
D.3 Method for the determination of the standard measurement uncertainty 59
D.3.1 Type A 59
D.3.2 Type B 60
D.4 Examples for the calculation of the measurement uncertainty 61
D.4.1 Measuring principle 61
D.4.2 Model equation 61
D.4.3 Measurement uncertainty budget considering the specification for the working standard 62
D.4.4 Measurement uncertainty budget considering the error of the working standard 65
D.5 Indication of the measurement uncertainty 67
Annex E (informative) Guidelines for overall laboratory setup 68
E.1 General 68
E.2 General conditions 68
E.3 Quality of mains supply 68

E.4 Reference standard 69
Annex F (normative) Multi-secondary voltage transformer 70
F.1 General 70
F.2 Definitions 70
F.3 Application 70
F.4 Technical requirements 71
F.5 Total accuracy of MTU with MSVT 72
Annex G (normative) Isolating current transformer (ICT) 73
G.1 General 73
G.2 Definitions 73
G.3 Application 73
G.4 Technical requirements 74
G.5 Wiring and terminals 74
G.6 Total accuracy of MTU with ICT 74
Bibliography 76

Figure C.1 – Test circuit diagram (informative) 54
Figure C.2 – Phase fired waveform 55
Figure C.3 – Informative distribution of harmonic content of phase fired waveform (the Fourier analysis is not complete) 55
Figure C.4 – Burst fired waveform 56
Figure C.5 – Informative distribution of harmonics (the Fourier analysis is not complete) 57
Figure D.1 – Measuring setup of the meter test arrangement 61
Figure F.1 – Testing of single-phase meters with closed link between the voltage and current circuits (variant 1) 71
Figure F.2 – Testing of single-phase meters with closed link between the voltage and current circuits (variant 2) 71
Figure G.1 – Testing of three-phase meters with closed link between the voltage and current circuits 73

Table 1 – Mains power supply condition 22
Table 2 – Test voltage circuit for each phase 22
Table 3 – Test current circuit for each phase 23
Table 4 – Setting of phase angle between each phase voltage and current circuit 23
Table 5 – Setting of frequency 23
Table 6 – Setting of harmonics 24
Table 7 – Standard electrical values for the standard meter 25
Table 8 – Electrical and mechanical values for the scanning head(s) 25
Table 9 – Parameters for the error calculation system 26
Table 10 – Information requirements 28
Table 11 – Climatic conditions 34
Table 12 – Surface temperature limits 34
Table 13 – AC voltage tests 36
Table 14 – Limits of variation of error of standard meters during immunity test 37
Table 15 – Relative error limits for the standard meter 40

Table 16 – Influence quantities 41
Table 17 – Recommended accuracy class of reference standard meter 46
Table 18 – Basic measurement table (recommended test points) 46
Table 19 – Limits of maximum permissible error (δW_{max}) of the complete MTU related to DUT 47
Table 20 – Limits of permissible values of standard deviation of MTU 48
Table A.1 – Symbols which may be used on metering equipment 52
Table B.1 – Reference conditions 53
Table D.1 – Coverage factors k for different effective degrees of freedom V_{eff} 59
Table D.2 – List 1 of quantities 63
Table D.3 – Readings 1 of the DUT 63
Table D.4 – Reading 1 of the standard meter 64
Table D.5 – Measurement uncertainty budget 1 64
Table D.6 – List 2 of quantities 65
Table D.7 – Readings 2 of the DUT 65
Table D.8 – Reading 2 of the standard meter 66
Table D.9 – Measurement uncertainty budget 2 67
Table E.1 – Mains supply quality 69
Table F.1 – Technical requirements of MSVTs 72
Table F.2 – Maximum permissible limits of error of MTU with MSVT 72
Table G.1 – Technical requirements of ICT 74
Table G.2 – Maximum permissible limits of error of MTU with ICT 75

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ELECTRICAL ENERGY METERS – TEST EQUIPMENT, TECHNIQUES AND PROCEDURES –

Part 1: Stationary meter test units (MTUs)

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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).

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

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…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 $\{m_1(T), m_2(T), ... m_N(T)\}$;

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

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

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

Note 2 to entry: The purchaser and the manufacturuer 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:

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

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 nth harmonic:

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

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:

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

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.

$$S = \sqrt{P^2 + Q^2} \tag{6}$$

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:

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

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:

$$Q = U_1 \cdot I_1 \cdot \sin\varphi \tag{8}$$

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 IEV 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].

$$Q = \sqrt{S^2 - P^2} \tag{9}$$

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)::

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

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.