BS EN 60255-1:2010

Measuring relays and protection equipment —

Part 1: Common requirements

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National foreword

This British Standard is the UK implementation of EN 60255-1:2010. It is identical to IEC 60255-1:2009. It supersedes BS EN 60255-6:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/95, Measuring relays and protection systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

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Foreword

The text of document 95/252/FDIS, future edition 1 of IEC 60255-1, prepared by IEC TC 95, Measuring relays and protection equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60255-1 on 2009-12-01.

This European Standard supersedes EN 60255-6:1994.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2010-09-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2012-12-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60255-1:2009 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61508	NOTE	Harmonized in EN 61508 series (not modified).
IEC 60255-5	NOTE	Harmonized as EN 60255-5:2001 (not modified).
IEC 60300-1	NOTE	Harmonized as EN 60300-1

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application 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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60044-1 (mod)	1996	Instrument transformers - Part 1: Current transformers	EN 60044-1	1999
IEC 60044-2 (mod)	1997	Instrument transformers - Part 2: Inductive voltage transformers	EN 60044-2	1999
IEC 60044-5	2004	Instrument transformers - Part 5: Capacitor voltage transformers	EN 60044-5	2004
IEC 60044-7	1999	Instrument transformers - Part 7: Electronic voltage transformers	EN 60044-7	2000
IEC 60044-8	2002	Instrument transformers - Part 8: Electronic current transformers	EN 60044-8	2002
IEC 60050-191	1990	International Electrotechnical Vocabulary (IEV) - Chapter 191: Dependability and quality of service	-	-
IEC 60050-447	2009	International Electrotechnical Vocabulary - Part 447: Measuring relays	-	-
IEC 60068-2-1	2007	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	2007
IEC 60068-2-2	2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	2007
IEC 60068-2-14	2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature	EN 60068-2-14	2009
IEC 60068-2-30	2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	2005
IEC 60068-2-78	2001	Environmental testing - Part 2-78: Tests - Test Cab: Damp heat, steady state	EN 60068-2-78	2001
IEC 60068-3-4	2001	Environmental testing - Part 3-4: Supporting documentation and guidance - Damp heat tests	EN 60068-3-4	2002
IEC 60255-11	2008	Measuring relays and protection equipment - Part 11: Voltage dips, short interruptions, variations and ripple on auxiliary power supply port	EN 60255-11	2010

Publication	Year	Title	EN/HD	Year
IEC 60255-21-1	1988	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section 1: Vibration tests (sinusoidal)	EN 60255-21-1	1995
IEC 60255-21-2	1988	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section 2: Shock and bump tests	EN 60255-21-2	1995
IEC 60255-21-3	1993	Electrical relays - Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment - Section 3: Seismic tests	EN 60255-21-3	1995
IEC 60255-22-2	2008	Measuring relays and protection equipment - Part 22-2: Electrical disturbance tests - Electrostatic discharge tests	EN 60255-22-2	2008
IEC 60255-22-4	2008	Measuring relays and protection equipment - Part 22-4: Electrical disturbance tests - Electrical fast transient/burst immunity test	EN 60255-22-4	2008
IEC 60255-22-5	2008	Measuring relays and protection equipment - Part 22-5: Electrical disturbance tests - Surge immunity test	EN 60255-22-5	200X[1)]
IEC 60255-22-7	2003	Electrical relays - Part 22-7: Electrical disturbance tests for measuring relays and protection equipment - Power frequency immunity tests	EN 60255-22-7	2003
IEC 60255-25	2000	Electrical relays - Part 25: Electromagnetic emission tests for measuring relays and protection equipment	EN 60255-25	2000
IEC 60255-26	2008	Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements	EN 60255-26	2009
IEC 60255-27	2005	Measuring relays and protection equipment - Part 27: Product safety requirements	EN 60255-27	2005
IEC 60255-1xx	Series	Measuring relays and protection equipment - Part 1xx: Protection functional standards	EN 60255-1xx	Series
IEC 60297-3-101	2004	Mechanical structures for electronic equipment - Dimensions of mechanical structures of the 482,6 mm (19 in) series - Part 3-101: Subracks and associated plug-in units	EN 60297-3-101	2004
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 1993
IEC 60688	-	Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals	EN 60688	-

[1)] To be ratified.

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Publication	Year	Title	EN/HD	Year
IEC 60721-3-3	-	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 3: Stationary use at weatherprotected locations	EN 60721-3-3	-
IEC/TS 61000-2-5	1995	Electromagnetic compatibility (EMC) - Part 2-5: Environment - Classification of electromagnetic environments - Basic EMC publication	-	-
IEC 61810	-	Electromechanical elementary relays - Part 1: General requirements	EN 61810	-
IEC 61810-2	-	Electromechanical elementary relays - Part 2: Reliability	EN 61810-2	-
IEC 61850	Series	Communication networks and systems in substations	EN 61850	Series
IEC 61850-9-2	-	Communication networks and systems in substations - Part 9-2: Specific Communication Service Mapping (SCSM) - Sampled values over ISO/IEC 8802-3	EN 61850-9-2	-

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INTRODUCTION

NUMBERING OF STANDARDS FALLING UNDER THE RESPONSIBILITY OF TC 95

In accordance with the decision taken at the technical committee 95 meeting in Paris on 2006-04-06 (item 12 of 95/191/RM) a new numbering system will be established of the standards falling under the responsibility of TC 95. Numbering of the standards will follow the following principle:

– common standards will start with IEC 60255 –;
– protection functional standards will start with IEC 60255-100 series;
– technical reports will start with IEC 60255-200 series.

The IEC 60255 series will consist of the following parts, under the general title *Measuring relays and protection equipment.* Five parts (Parts 3, 8, 12, 13 and 16) will be renumbered and Part 6 will be replaced by Part 1.

a) Common standards:

Part 1: Common requirements

Part 11: Interruptions to and alternating component (ripple) in d.c. auxiliary energizing quantity of measuring relays

Part 21: Vibration, shock, bump and seismic tests

Part 22: Electrical disturbance tests

Part 24: Common format for transient data exchange (COMTRADE) for power systems

Part 25: Electromagnetic emission tests

Part 26: Electromagnetic compatibility requirements

Part 27: Product safety requirements

b) Protection functional standards:

121 Functional requirements for distance protection (revision of IEC 60255-16)

124 Functional requirements for volts per hertz protection

125 Functional requirements for synchronizing or synchronism-check

127 Functional requirements for over/under voltage protection (revision of IEC 60255-3) (including the phase, neutral, residual and negative sequence)

132 Functional requirements for over/under power protection (revision of IEC 60255-12) (including the real reactive and power factor)

140 Functional requirements for loss of excitation protection

149 Functional requirements for thermal protection (revision of IEC 60255-8)

151 Functional requirements for over/under current protection (revision of IEC 60255-3) (including the phase, ground, residual and negative sequence)

160 Functional requirements for voltage or current unbalance protection

167 Functional requirements for directional current protection

178 Functional requirements for power swing/out-of-step protection

179 Functional requirements for reclosing

181 Functional requirements for frequency relay (including over/under, rate of change)

185 Functional requirements for teleprotection function

187 Functional requirements for differential protection (revision of IEC 60255-13) (including generator, transformer, busbar, line and restricted earth fault)

195 Functional requirements for synchrophasor measurement

NOTE 1 The functional standard for synchrophasor measurement may be developed from IEEE Std C37.118:1995 [1][1].

NOTE 2 The last two digits of the part of the proposed functional standard new numbering correspond to device function numbers as established in IEEE Std C37.2:1996[2].

c) Technical reports:

Part 200: Application guide for generator protection

Part 201: Application guide for motor protection

Part 202: Application guide for transformer protection

Part 203: Application guide for reactor protection

Part 204: Application guide for bus protection

Part 205: Application guide for line protection

Part 206: Application guide for breaker failure protection

1 Figures in square brackets refer to the bibliography.

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 1: Common requirements

1 Scope

This part of IEC 60255 specifies common rules and requirements applicable to measuring relays and protection equipment including any combination of devices to form schemes for power system protection such as control, monitoring and process interface equipment in order to obtain uniformity of requirements and tests.

All measuring relays and protection equipment used for protection within the power system environment are covered by this standard. Other standards in this series may define their own requirements which in such cases shall take precedence.

For special applications (marine, aerospace, explosive atmospheres, computers, etc.), the general requirements within this standard may need to be enhanced by additional special requirements.

The requirements are applicable only to relays in new condition. All tests in this standard are type tests, unless otherwise declared.

2 Normative references

The following referenced documents are indispensable for the application 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 60044-1:1996*, Instrument transformers – Part 1: Current transformers*

IEC 60044-2:1997, *Instrument transformers – Part 2: Inductive voltage transformers*

IEC 60044-5:2004, *Instrument transformers – Part 5: Capacitor voltage transformers*

IEC 60044-7:1999, *Instrument transformers – Part 7: Electronic voltage transformers*

IEC 60044-8:2002*, Instrument transformers – Part 8: Electronic current transformers*

IEC 60050-191:1990, *Internation Electrotechnical Vocabulary – Chapter 191: Dependability and quality of service*

IEC 60050-447:2009*, International Electrotechnical Vocabulary – Part 447: Measuring relays*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

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IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60068-3-4:2001, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60255-11:2008, *Measuring relays and protection equipment – Part 11: Voltage dips, short interruptions, variations and ripple on auxiliary power supply port*

IEC 60255-21-1:1988, *Electrical relays – Part 21-1: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Vibration tests (sinusoidal)*

IEC 60255-21-2:1988, *Electrical relays – Part 21-2: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Shock and bump tests*

IEC 60255-21-3:1993, *Electrical relays – Part 21-3: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Seismic tests*

IEC 60255-22-2:2008, *Measuring relays and protection equipment – Part 22-2: Electrical disturbance tests – Electrostatic discharge tests*

IEC 60255-22-4:2008, *Measuring relays and protection equipment – Part 22-4: Electrical disturbance tests – Electrical fast transient/burst immunity test*

IEC 60255-22-5:2008, *Measuring relays and protection equipment – Part 22-5: Electrical disturbance tests – Surge immunity test*

IEC 60255-22-7:2003, *Electrical relays – Part 22-7: Electrical disturbance tests for measuring relays and protection equipment – Power frequency immunity tests*

IEC 60255-25:2000, *Electrical relays – Part 25: Electromagnetic emission tests for measuring relays and protection equipment*

IEC 60255-26:2008, *Measuring relays and protection equipment – Part 26: Electromagnetic compatibility requirements*

IEC 60255-27:2005, *Measuring relays and protection equipment – Part 27: Product safety equipment*

IEC 60255-100 (all parts), *Measuring relays and protection equipment – Parts 1XX: Protection functional standards*

IEC 60297-3-101:2004, *Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in) series – Part 3-101: Subracks and associated plug-in units*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60688, *Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals*

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

IEC/TR 61000-2-5:1995, *Electromagnetic compatability (EMC) – Part 2: Environment* – Section 5: *Classification of electromagnetic environments – Basic EMC publication*

IEC 61810-1, *Electromechanical elementary relays – Part 1: General requirements*

IEC 61810-2, *Electromechanical elementary relays – Part 2: Reliability*

IEC 61850 (all parts), *Communication networks and systems in substations*

IEC 61850-9-2, *Communication networks and systems in substations – Part 9-2: Specific Communication Service Mapping (SCSM) – Sampled values over ISO/IEC 8802-3*

3 Terms and definitions

For the purposes of this document, the terms and definitions of IEC 60050-447, as well as the following, apply.

3.1
absolute error
difference between a measured operate value of the characteristic quantity or a measured value of a specific time and its declared value (e.g. setting value).

3.2
alternating component
in d.c. expressed as a percentage of the difference between the maximum value U_{max} and the minimum value U_{min} of a pulsating d.c. voltage to the mean value U_0 of this voltage

$$\frac{U_{max} - U_{min}}{U_0} \times 100\%$$

3.3
analogue inputs and outputs
current or voltage inputs/outputs whose values are directly proportional to physical measured quantities i.e. transducer input

3.4
assigned error
error limits within which the manufacturer declares that any device of a given type will perform under the reference conditions

3.5
binary inputs/outputs
inputs/outputs which have either an on or off state and can be either physical connections or supplied via a communication port

3.6
dynamic performance
characteristics defining the ability of the relay to achieve the intended functions under fault conditions (for example single phase to earth fault) and/or abnormal system conditions which occur at the power system frequency (for example: power swings, harmonics, etc.)

3.7
equipment
single apparatus or set of devices or apparatuses, or a set of main devices of an installation, or all devices necessary to perform a specific task

NOTE 1 Examples of equipment are a power transformer, the equipment of a substation, measuring equipment.

NOTE 2 For the purpose of this standard, equipment is a measuring relay and protection equipment.

3.8
equipment under test
EUT
equipment submitted to a test, including any accessories, unless otherwise specified

3.9
influence quantity
quantity not essential for the performance of a device but affecting its performance, e.g, temperature, humidity, etc.

3.10
integrated protection relay
single apparatus taking a range of input measurements and performing a multitude of protection functions on these measurements

3.11
intrinsic accuracy
quality which characterizes the ability of the device, when used under reference conditions, to operate at values close to the true operating values of input energizing quantities and at times close to the time setting values or to the absolute declared operating times

NOTE 1 See Annex B for additional information.

NOTE 2 Intrinsic accuracy depends only on uncertainty associated with the components of a measuring relay and protection equipment under reference conditions.

NOTE 3 Accuracy is all the better when the operate value is closer to the corresponding true value and time closer to time setting values or to the absolute declared time.

3.12
mean value of measurements
quotient of the algebraic sum of the measurements values by the number of measurements

NOTE Mean value may be expressed as an absolute value, a relative value or a percentage of its setting value.

3.13
normal use
use of the device installed and operated under normal service conditions, with all covers and protective measures in place

3.14
operating accuracy
quality which characterizes the ability of the device, when submitted to influence quantities within their tolerance ranges, to operate at values close to the true operating values of input energizing quantities and at times close to the time setting values or to the absolute declared operating times

NOTE 1 See Annex B for additional information.

NOTE 2 Operating accuracy of measuring relay and protection equipment depends on intrinsic accuracy and uncertainty associated with the variation of performance of components due to influence quantities.

NOTE 3 Accuracy increases (or it is higher) when the operate value is closer to the corresponding true value and time closer to time setting values or to the absolute declared time.

3.15
overall system accuracy
accuracy of a protection system, considering intrinsic accuracy and operating accuracy of the device, to which is added uncertainties and variations due to external sensors accuracy and to external wires

NOTE See Annex B for additional information.

3.16
primary relay
measuring relay directly energized by the current or voltage in a main circuit, without any intermediate instrument transformer, shunt or transducer or with a built-in instrument transformer

3.17
product family
range of products based on a common hardware and/or software platform

3.18
routine test
conformity test made on each individual device during or after manufacture

3.19
secondary relay
measuring relay energized by the quantity (e.g. electric current or voltage) derived from an instrument transformer or transducer

3.20
shunt relay
measuring relay energized by the current derived from a shunt in a main circuit

3.21
transient response
reaction of the device under transient system conditions which do not occur at the power system frequency (for example magnetizing inrush, capacitive voltage transformer transients, etc.).

3.22
type test
test of one or more devices made to a given design, to check if these devices comply with the requirements of the standard concerned.

4 Environmental conditions

4.1 General

This clause specifies environmental conditions for weather-protected equipment during stationary use, maintenance and repair.

4.2 Normal environmental conditions

Measuring relays and protection equipment are intended to be used in the normal service conditions listed in Table 1.

Table 1 – Normal environmental conditions

Environmental parameters		Conditions
Ambient air temperature [a]	Upper limit	≤ +55 °C
	Lower limit	≥ –10 °C [e]
Solar radiations		Negligible
Altitude		≤ 2 000 m
Air pollution by dust, salt, smoke, corrosive/flammable gas, vapours		No significant air pollution [b]
Relative humidity: 24 h average		From 5 % to 95 % [c]
Vibration, earth tremors		According to IEC 60255-21 series environment Class 0 or Class 1
Electromagnetic disturbances		Electromagnetic environment defined by immunity test levels of IEC 60255-26, Class B [d]

[a] The ambient air temperature is the maximum or minimum temperature around the enclosure of the protection relay. Depending on the type of climate and the type of weather-protected location where a measuring relay and protection equipment is mounted, temperature limits may be more or less severe. Consequently, the equipment should be capable of operating under one of the preferred standard temperature ranges listed in 5.8.

[b] These conditions correspond to maximum values given for classes 3C1 and 3S1 in IEC 60721-3-3.

[c] No condensation or ice is considered.

[d] This is in line with basic standard IEC/TR 61000-2-5, classification of electronic environments, for a location class type 5 listing attributes for a heavy industrial location, a generating station or a switch-yard.

[e] Display may become dark or un-readable at low temperature; however, this condition does not affect the proper operation of the protection or other functions.

4.3 Special environmental conditions

When equipment is used under conditions different from the normal environmental conditions given in Table 1, the user shall refer to Table 2. In this case, there shall be an agreement between the manufacturer and the user.

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Table 2 – Special environmental conditions

Environmental parameters		Conditions
Ambient air temperature [a]	Upper limit	> +55 °C
	Lower limit	< –10 °C [g]
Altitude		> 2 000 m [b]
Air pollution by dust, salt, smoke, corrosive/flammable gas, vapours		Location in urban areas with industrial activities and without special precautions to minimize the presence of sand or dust [c]
Relative humidity: 24 h average		> 95 % [d]
Vibration, seismic conditions		According to IEC 60255-21 series environment, Class 2 [e]
Electromagnetic disturbances		Electromagnetic environment defined by immunity test levels of IEC 60255-26 [f]

[a] The ambient air temperature is the maximum or minimum temperature around the enclosure of the protection relay.

[b] For altitudes higher than 2 000 m users shall refer to IEC 60664-1.

[c] These conditions correspond to maximum values given for classes 3C2 and 3S2 in IEC 60721-3-3.

[d] In Tropical indoor conditions, the average value of relative humidity measured during a period of 24 h can be 98 %.

[e] This severity class concerns measuring relays and protection equipment for which a very high margin of security in service is required, or where the seismic shock level is very high.

[f] Special environmental conditions for electromagnetic disturbances imply that the measuring relay and protection equipment is submitted to severity class A of IEC 60255-22-4, suitable for typical industrial environment, and/or to severity class A of IEC 60255-22-7. Applicable to substations with high earth fault currents and where wiring practice allows the d.c. status inputs to be wired in open loops (go and return wire in different multicore cable).

[g] Display may become dark or un-readable at low temperature; however, this condition does not affect the proper operation of the protection or other functions.

4.4 Storage conditions

Measuring relays and protection equipment are intended to be stored in their supplied packaging. The temperature range of storage shall be chosen from the ranges given in 5.8 and stated by the manufacturer.

5 Ratings

5.1 General

The rated values listed below are preferred values for specification purposes. Other values may be adopted according to conditions of operation and use.

5.2 Rated voltage

5.2.1 Input energizing voltage

5.2.1.1 Primary relay

Manufacturer shall declare rated values for a.c. or d.c.

5.2.1.2 Secondary relay

The preferred rated values of a.c. voltages, in r.m.s. value, are in line with IEC 60044-2 and IEC 60044-5 and are given below, together with those values multiplied by 1/3 or $\sqrt{3}$ or $1/\sqrt{3}$.

100 V; 110 V; 115 V; 120 V; 200 V; 220 V; 230 V

For equipment compatible with electronic voltage transformers (e.g. low power analogue VT), the preferred values shall be those stated in IEC 60044-7.

5.2.1.3 Shunt relay

The preferred rated values of d.c. voltages are given below:

30 mV; 45 mV; 50 mV; 60 mV; 75 mV; 100 mV; 150 mV; 200 mV; 300 mV; 600 mV.

5.2.2 Auxiliary energizing voltage

5.2.2.1 AC voltage

The preferred rated values of a.c. voltages, in r.m.s value, are given below, together with those values multiplied by $\sqrt{3}$ or $1/\sqrt{3}$:

100 V; 110 V; 115 V; 120 V; 200 V; 230 V

5.2.2.2 DC voltage

The preferred rated values of d.c. voltages are given below:

12 V; 24 V; 48 V; 60 V; 110 V; 125 V; 220 V; 250 V.

5.2.2.3 Operating range

The preferred operating range is 80 % to 110 % of the rated voltage.

5.2.3 Rated insulation voltage

The rated insulation voltage of one or all of the circuits of the equipment shall be chosen from the values stated in IEC 60255-27.

5.3 Rated current

5.3.1 Input energizing current

5.3.1.1 Primary relay

Manufacturer shall declare rated values for a.c. or d.c. currents.

5.3.1.2 Secondary relay

The preferred rated values of a.c. currents, in r.m.s value, are in line with IEC 60044-1 and are 1 A or 5 A.

For equipment compatible with electronic current transformers (e.g. low power analogue CT), the preferred values shall be those stated in IEC 60044-8.

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5.3.2 Auxiliary energizing current

The manufacturer shall declare rated values for a.c. currents.

5.4 Binary input and output

5.4.1 Binary input

The manufacturer shall declare the ratings.

5.4.2 Binary output

The manufacturer shall declare the ratings.

5.5 Transducer analogue input and output

5.5.1 Transducer analogue input

The manufacturer shall declare the ratings.

5.5.2 Transducer analogue output

The manufacturer shall declare the ratings.

5.6 Frequency

5.6.1 Rated frequency

The standard values of the rated frequency are as follows:

16,7 Hz; 50 Hz; 60 Hz.

5.6.2 Frequency operating range

The preferred frequency operating range of the equipment shall be specified according to one of the following ranges:

–5 % to +5 %; –5 % to +10 %; –10 % to +5 % or –10 % to +10 % of the rated frequency.

For protection equipment designed to operate over a wide frequency range, e.g. generator protection then this frequency range shall be specified.

5.7 Rated burden

The burden for the voltage transformers, current transformers (at rated quantity), power supply (a.c. including power factor/d.c.) at quiescent state and maximum load and for other energized circuits shall be specified.

The maximum start-up inrush current of the power supply circuits shall also be stated.

5.8 Rated ambient temperature

Unless otherwise stated, the preferred rated ambient temperature is –10 °C to +55 °C for the operation of the equipment. Other recommended values are:

–5 °C to +40 °C	0 °C to +40 °C	0 °C to +45 °C	–10 °C to +50 °C
–25 °C to +40 °C	–20 °C to +55 °C	–25 °C to +55 °C	–20 °C to +60 °C
–20 °C to +70 °C	–25 °C to +70 °C	–30 °C to +65 °C	–40 °C to +70 °C

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6 Design and construction

6.1 Marking

The equipment shall be marked in accordance with IEC 60255-27.

6.2 Dimensions

The manufacturer shall declare the dimensions of the equipment. However, where the equipment is rack mounted then the dimensions should be in accordance with IEC 60297-3-101.

6.3 Enclosure protection

The equipment shall meet the requirements of IEC 60255-27.

6.4 Product safety requirements

The equipment shall comply with the requirements of IEC 60255-27.

NOTE The product safety requirements include the dielectric tests and thermal short time ratings.

6.5 Functional performance requirements

6.5.1 General

The protection function operation is specified in the functional standards (see the IEC 60255-100 series).

The accuracy requested in the functional standards shall take into account the requirements of 6.5.2 to 6.5.5 unless the functional standard defines a specific alternative definition. In all cases, the manufacturer shall state the limitations on their supplied equipment, i.e. operating time measured from applied voltage and current to output contact operation.

6.5.2 Intrinsic accuracy

6.5.2.1 General

An assigned error of the equipment under the test reference conditions as stated in Table 10 shall be declared by the manufacturer. The actual measurement errors of the equipment shall be less than or equal to the declared value of assigned error under these conditions taking into account the test equipment uncertainty.

When the accuracy is expressed as a percentage it should be expressed as a number selected from the following series:

0,2 %; 0,5 %; 1,0 %; 1,5 %; 2,5 %; 5,0 %; 7,5 %; 10 %; 20 %.

NOTE Annex B gives explanations about intrinsic accuracy and operating accuracy.

The maximum current for equipment operation within its stated accuracy shall be declared by the manufacturer.

6.5.2.2 Accuracy relating to the characteristic quantity

The relay measuring accuracy related to the characteristic quantity as defined in the IEC 60255-100 series shall be expressed as a maximum error. The maximum error shall be verified from 5 consecutive measurements.

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The accuracy relating to the characteristic quantity shall be expressed as either:

- an absolute quantity, or
- a percentage of the setting value, or
- a percentage of setting value together with a fixed absolute quantity.

6.5.2.3 Accuracy specification of time delayed elements

The relay measuring accuracy related to operating time as defined in the IEC 60255-100 series shall be expressed as a maximum error. The maximum error shall be verified from at least 5 consecutive measurements.

The accuracy relating to time shall be expressed as either:

- a percentage of time setting, or
- a percentage of the time setting value, together with a fixed minimum time error (where this may exceed the percentage value). For example 5 % or 20 ms, whichever is the greater, or
- a fixed absolute quantity. For example 20 ms.

6.5.2.4 Accuracy specification of instantaneous elements

The relay measuring accuracy related to time reaction of instantaneous elements as defined in the IEC 60255-100 series shall be expressed as a maximum error. The maximum error shall be verified from 5 consecutive measurements.

The maximum operating time shall be expressed as an absolute time. For example 20 ms.

6.5.3 Operating accuracy

The manufacturer shall declare the variations due to influencing quantities or factors, such as temperature, auxiliary energizing quantity, harmonics, frequency, etc. The IEC 60255-100 series defines which influencing quantities are relevant. The determination of variation in error due to changing any one influencing quantity or factor between the limits of its nominal range shall be made under the test reference conditions as stated in Table 10 with the exception of the influencing quantity or factor for which the variation is being determined.

The accuracy with influencing quantities should be expressed as detailed in 6.5.2.

NOTE Annex B gives explanations about intrinsic accuracy and operating accuracy.

6.5.4 Performance under dynamic system conditions

The manufacturer shall declare the dynamic performance of the protection functions in accordance with the relevant protection functional standard (IEC 60255-100 series).

6.5.5 Performance under transient signal conditions

The manufacturer shall declare the transient response of the protection functions in accordance with the relevant protection functional standard (IEC 60255-100 series).

6.5.6 Multifunctional protection relay

The manufacturer should declare the performance of each protection function when used in a multifunctional protection relay.

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6.5.7 Programmable logic

The manufacturer shall declare any performance limitation of the protection function when used in conjunction with programmable logic if used.

6.6 Communication protocols

The communication protocols and the type of communication media, used for communication with the equipment, shall be stated by the manufacturer. Protocols preferred are those with an IEC standard. Conformance testing shall be performed to ensure that they comply with the relevant standard or specification.

6.7 Binary input and output

6.7.1 Binary input

The standard arrangement for binary inputs is an opto isolated input. Other forms of input are TTL logic, data messages, i.e. the IEC 61850 series, etc. The manufacturer shall in all cases specify their performance. For an opto isolated input the following requirements apply.

a) The d.c. only binary inputs shall register a change of state when a valid d.c. voltage is applied; the binary inputs should not register a change of state when a power frequency a.c. voltage is applied in accordance with IEC 60255-22-7.

b) The d.c. operating voltage rating and other conditions for binary inputs should be as per those specified in 5.2.2.2 and 5.2.2.3. When exceeding the voltage ratings in 5.2.2.3, the deviation shall be agreed between the manufacturer and the user.

c) For dual rated binary inputs (d.c./a.c.) the operating voltage rating and other conditions for binary inputs should be as per those specified in 5.2.2.1 to 5.2.2.3.

6.7.2 Binary output

The standard arrangement for binary outputs is an output contact. Other forms of output are TTL logic, data messages, i.e. the IEC 61850 series, etc. The manufacturer shall in the case of an output contact specify the ratings as per 6.11. For other outputs the manufacturer shall specify their performance.

6.8 Transducer analogue input and output

6.8.1 Transducer analogue input

The analogue input characteristic shall be defined by the manufacturer but should cover one of the operating ranges defined in IEC 60688.

6.8.2 Transducer analogue output

The analogue output characteristic shall be defined by the manufacturer but should cover one of the operating ranges defined in IEC 60688.

6.9 Input circuit for energizing quantities

6.9.1 Characteristic energizing quantity

The input characteristic shall be defined by the manufacturer.

For equipment operated via an electromagnetic CT, the maximum current for equipment operation within its stated accuracy shall be declared by the manufacturer. The equipment shall be capable of operating within its declared accuracy for an applied current of 20 times rated current (not applicable for undercurrent or sensitive current measurements). In addition

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the 1 s short time thermal withstand shall be determined and it shall be verified that the EUT is capable of operating (outside of accuracy range).

For equipment operated via an electromagnetic VT, the maximum voltage for equipment operation within its stated accuracy shall be declared by the manufacturer. In addition the 10 s short time withstand shall be determined and it shall be verified that the EUT is capable of operating (outside of accuracy range).

For equipment designed to take digitized analogue samples over a process bus the manufacturer shall comply with IEC 61850-9-2.

6.9.2 Auxiliary energizing quantity

The input characteristic shall be defined by the manufacturer.

6.10 Burden tests

6.10.1 Burden for voltage transformers

Energizing voltage inputs of the relay are energized at rated input energizing voltage, and the test shall be carried out by voltamperes (VA) measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.2 Burden for current transformers

Energizing current inputs of the relay are energized at rated input energizing current, and the test shall be carried out by voltamperes (VA) measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.3 Burden for AC power supply

6.10.3.1 Quiescent state burden

The relay is powered at rated auxiliary energizing voltage without any energizing quantities input, and the test shall be carried out by voltamperes (VA) measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.3.2 Maximum load

The relay is powered at rated auxiliary energizing voltage, and energized with energizing quantities that cause relay to operate and drive at least 50 % of all outputs. The test shall be carried out by voltamperes (VA) measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.3.3 Inrush current and power-up duration

The relay is switched on at rated auxiliary energizing voltage without any energizing quantities input. The peak value of input current during power-up, the duration from switching instant to the instant that input current gets to within 10 % of quiescent state current shall be recorded. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.4 Burden for DC power supply

6.10.4.1 Quiescent state burden

The relay is powered at rated auxiliary energizing voltage without any energizing quantities input and the test shall be carried out by Watt measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.4.2 Maximum load

The relay is powered at rated auxiliary energizing voltage, and energized with energizing quantities that cause relay to operate and drive at least 50 % of all outputs. The test shall be carried out by Watt measurement. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.4.3 Inrush current and power-up duration

The relay is switched on at rated auxiliary energizing voltage without any energizing quantities input. The peak value of input current during power-up, the duration from switching instant to the instant that input current gets to within 10 % of quiescent state current shall be recorded. The maximum value of 5 consecutive tests shall be used for burden claim.

6.10.5 Burden for binary input

At least one binary input shall be tested for each binary inputs group with the same rated voltage. The binary input is energized at rated voltage, and the value of input current shall be recorded. The maximum value of 5 consecutive tests shall be used for burden claim.

6.11 Contact performance

The performance of the equipment contact outputs (mechanical and static) shall be specified according to IEC 61810-1.

The manufacturer shall state the following:

- Contact voltage
- Limiting making capacity
- Contact current, continuous and short duration
- Limiting breaking capacity, d.c. resistive and inductive, a.c. resistive and inductive
- Mechanical and electrical endurance (loaded and unloaded)

Where the contacts of a tripping relay are intended to be connected to tripping coils of switchgear and controlgear, their contact performance shall comply with the following characteristics:

a) Mechanical endurance
   - Unloaded contact ≥10 000 cycles
   - Making ≥1 000 cycles
   - Breaking ≥1 000 cycles

b) Limiting making capacity: ≥1 000 W at L/R = 40 ms

c) Contact current:
   - Continuous ≥5 A,
   - Short time ≥30 A, 200 ms
   - The duty cycle for the short time rating shall consist of the sequence 200 ms on, 15 s off (current is interrupted by independent means at the end of each on cycle).

d) Limiting breaking capacity: ≥ 30 W at L/R = 40 ms

e) The manufacturer shall declare the maximum contact voltage for the items a) to d) in accordance with 5.2.2.2.

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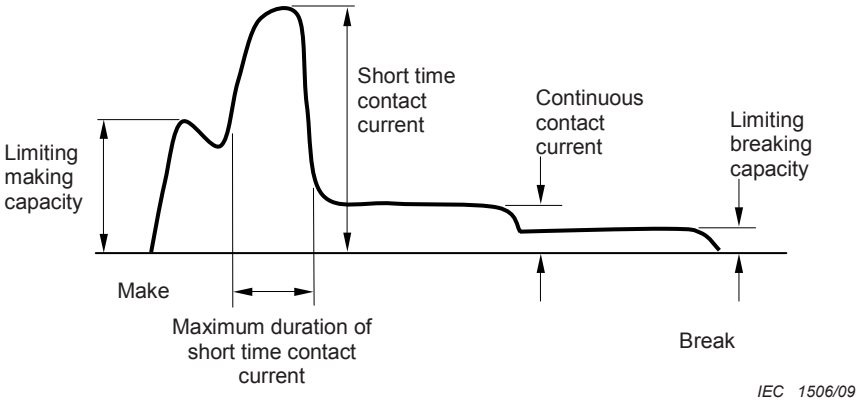

Figure 1 – Contact performance parameters

6.12 Climatic performance

6.12.1 General

The characteristics of the relay shall not vary by more than the published tolerance for temperatures within the declared operating range. The effects of temperature on the component parts of the equipment that may result in a visual change but not affect the operational accuracy of the equipment (i.e. darkening of LCD display) shall be declared.

The manufacturer shall declare whether operation at the specified accuracy can be achieved when power is initially applied to the equipment after all components have been allowed stabilise at the ambient temperature. If the specified accuracy is achieved only after the unit is energized for a period of time, the manufacturer shall specify the estimated stabilization time required.

The equipment shall comply with the requirements of both change of temperature and storage and operating temperature tests.

NOTE Annex A gives guidance on test settings.

6.12.2 Verification procedure

6.12.2.1 Functional verification procedure

The verification procedure shall ensure that the equipment is in accordance with its specification and that it functions correctly during the initial measurement at the beginning of the test sequence and maintains its design characteristics throughout all the following individual tests where this has been specified. The initial and final measurements shall consist of a visual and a performance verification test. Measurements made during a test shall consist of a performance verification test.

In a test sequence where the final measurement of the previous test corresponds to the initial measurement of the succeeding individual test, it is not necessary to do these measurements twice, i.e. once is sufficient.

6.12.2.2 Measurement of insulation resistance

The measurement should be performed as a test following environmental testing to ensure that the insulation has not been over-stressed and weakened by the applied tests.

The measuring voltage shall be applied directly to the equipment terminals.

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The insulation resistance shall be determined when a steady value has been reached and at least 5 s after applying a d.c. voltage of 500 V ± 10 %.

For equipment in a new condition, the insulation resistance shall not be less than 100 MΩ at 500 V d.c. After the damp heat type test, the insulation resistance shall not be less than 10 MΩ at 500 V d.c., after a recovery time of between 1 h and 2 h, as stated in Tables 8 and 9.

6.12.2.3 Dielectric type test

The dielectric withstand shall be performed as a test following environmental testing to ensure that the insulation has not been over-stressed and weakened by the applied tests.

The type test shall be applied to the following groups:

- between each circuit and the accessible conductive parts, the terminals of each independent circuit being connected together;
- between independent circuits, the terminals of each independent circuit being connected together.

The independent circuits are those specified by the manufacturer. The manufacturer shall declare the dielectric voltage withstand for open metallic contacts. No tests should be applied across contacts when transient suppression devices are fitted. Circuits not involved in the tests shall be connected together and to earth.

Circuits specified for the same rated insulation voltage may be connected together when being tested to the exposed conductive parts.

The test voltages shall be applied directly to the terminals.

6.12.2.4 Protective bonding resistance – Type test

The measurement shall be performed as a test following damp heat environmental testing to ensure that any corrosion has not caused the exposed conductive parts and terminations connected to the protective earth conductor for protection against any electric shock hazard to have an excessive resistance.

For equipment where the protective earth connection is by means of one core of a multi-cored cable, the cable is not included in the measurement, provided that the cable is supplied by a suitably rated protective device which takes into account the size of the conductor.

The compliance of such parts with protective bonding resistance type test requirements shall be determined, using the following test parameters:

- the test current shall be twice that of the maximum current rating of the overcurrent protection means, specified in the user documentation;
- the test voltage shall not exceed 12 V r.m.s. a.c. or 12 V d.c.;
- the test duration shall be 60 s;
- the resistance between the protective conductor terminal and the part under test shall not exceed 0,1 Ω.

6.12.2.5 Protective bonding continuity – Routine test

The protective bonding continuity shall be checked as part of the routine tests on all equipment as per the requirements of IEC 60255-27.

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6.12.3 Climatic environmental tests

6.12.3.1 Dry heat test – Operational

The dry heat operational test shall be performed to prove the resistance of the equipment to heat whilst operational and to determine any variation in performance due to temperature. See Table 3.

Table 3 – Dry heat test – operational

Subject	Test conditions
Test reference	Test Bd of IEC 60068-2-2
Preconditioning	According to the manufacturer's specifications
Initial measurement	According to 6.12.2
Conditions	Operated at manufacturer's rated load/current [a]
Operational temperature	As per manufacturer's maximum specified operating temperature, value should be chosen from 6.5.2 of IEC 60068-2-2. Maximum rate of change of temperature 1 °C per min, over a 5 min period
Accuracy	±2 °C (see 6.2 of IEC 60068-2-2)
Humidity	According to 6.8.2 of IEC 60068-2-2, test Bd
Duration of exposure	16 h minimum
Measuring and/or loading	Correct function at rated load/current
Recovery procedure: - time - climatic conditions - power supply	See 6.11 of IEC 60068-2-2. 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10. Power supply switched off
Final measurements	According to 6.12.2

[a] The manufacturer should declare the number of binary input circuits, and output relays energized and carrying maximum rated current, during the test.

6.12.3.2 Cold test – Operational

The operational cold test shall be performed to prove the resistance of the equipment to cold, whilst operational and to determine any variation in performance due to temperature. See Table 4.

Table 4 – Cold test – Operational

Subject	Test conditions
Test reference	Test Ad of IEC 60068-2-1
Preconditioning	According to the manufacturer's specifications
Initial measurement	According to 6.12.2
Conditions	Operated at manufacturer's rated load/current [a]
Operational temperature	As per manufacturer's minimum specified operating temperature, value should be chosen from 6.6.1 of IEC 60068-2-1. Maximum rate of change of temperature 1 °C per min, over a 5 min period
Accuracy	±3 °C (see 6.2 of IEC 60068-2-1)
Humidity	Not applicable
Duration of exposure	16 h minimum
Measuring and/or loading	Correct function at rated load/current
Recovery procedure: - time - climatic conditions - power supply	See 6.12 of IEC 60068-2-1. 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10 Power supply switched off
Final measurements	According to 6.12.2

[a] The manufacturer should declare the number of binary input circuits, and output relays energized and carrying maximum rated current, during the test.

6.12.3.3 Dry heat test at maximum storage temperature

The dry heat storage test shall be performed to prove the resistance of the equipment to storage heat. See Table 5.

Table 5 – Dry heat test, storage temperature

Subject	Test conditions
Test reference	Test Bb of IEC 60068-2-2
Preconditioning	According to the manufacturer's specifications
Initial measurement	According to 6.12.2
Conditions	Unenergized
Storage temperature	As per manufacturer's maximum specified storage temperature, value should be chosen from 6.5.2 of IEC 60068-2-2. Maximum rate of change of temperature 1 °C per min, over a 5 min period
Accuracy	± 2 °C (see 6.2 of IEC 60068-2-2)
Humidity	According to 6.8.2 of IEC 60068-2-2, test Bb
Duration of exposure	16 h minimum
Measuring and/or loading	Not applicable
Recovery procedure: - time - climatic conditions - power supply	See 6.11 of IEC 60068-2-2. 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10. Power supply switched off
Final measurements	According to 6.12.2

6.12.3.4 Cold test at minimum storage temperature

The cold storage test shall be performed to prove the resistance of the equipment to cold storage. See Table 6.

Table 6 – Cold test, storage temperature

Subject	Test conditions
Test reference	Test Ab of IEC 60068-2-1
Preconditioning	According to the manufacturer's specifications
Initial measurement	According to 6.12.2
Conditions	Unenergized
Storage temperature	As per manufacturer's minimum specified storage temperature, value should be chosen from 6.6.1 of IEC 60068-2-1. Maximum rate of change of temperature 1 °C per min, over a 5 min period
Accuracy	± 3 °C (see 6.2 of IEC 60068-2-1)
Humidity	Not applicable
Duration of exposure	16 h minimum
Measuring and/or loading	Not applicable
Recovery procedure: - time - climatic conditions - power supply	See 6.12 of IEC 60068-2-1. 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10. Power supply switched off
Final measurements	According to 6.12.2

6.12.3.5 Change of temperature test

The change of temperature test shall be performed to prove the resistance of the equipment to rapid changes in temperature. See Table 7.

Table 7 – Cyclic temperature test

Subject	Test conditions
Test reference	Test Nb: IEC 60068-2-14:2009
Preconditioning	Stabilized in test chamber at 20 °C ± 2 °C, for 1 h
Initial measurement	According to 6.12.2
Conditions	During the test the equipment shall be continuously energized and maintained in the in-service condition, with any influencing quantity set to its reference condition
Temperature	Lower temperature as per manufacturer's minimum specified operating temperature, value should be chosen from 6.6.1 of IEC 60068-2-1. Upper temperature as per manufacturer's maximum specified operating temperature, value should be chosen from 6.5.2 of IEC 60068-2-2. Test cycle, including ramp down and up as per IEC 60068-2-14, Figure 2, ramp rate 1 °C ±0,2 °C/min, dwell at upper and lower temperatures 3 h.
Duration of exposure	5 cycles
Measuring and/or loading	Equipment loaded according to 6.12.2
Recovery procedure: - time - climatic conditions - power supply	See 7.3 of IEC 60068-2-14:2009 1 h minimum, all tests to be conducted after this period. Standard reference conditions as stated in Table 10. Equipment energized
Final measurements	According to 6.12.2
NOTE The manufacturer should declare the number of binary input circuits, and output relays energized during the test.	

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6.12.3.6 Damp heat steady-state test

The damp heat steady-state test shall be performed to prove the resistance of the equipment to prolonged exposure to high humidity atmospheres. See Table 8.

Table 8 – Damp heat steady state test

Subject	Test conditions
Test reference	Test Cab of IEC 60068-2-78
Preconditioning	According to the manufacturer's specifications
Initial measurement	According to 6.12.2
Conditions	During the test the equipment shall be continuously energized and maintained in the in-service condition or as otherwise specified by the manufacturer, with any influencing quantity set to its reference condition
Temperature	As per manufacturer's claim (value should be chosen from Clause 5 of IEC 60068-2-78, tolerance ± 2 °C)
Humidity	(93 ± 3) %
Duration of exposure	10 days minimum
Measuring and/or loading	Equipment loaded according to 6.12.2
Recovery procedure: - time - climatic conditions - power supply	See Clause 9 of IEC 60068-2-78 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10. Equipment not energized
Final measurements	According to 6.12.2
NOTE 1 All external and internal condensation should be removed by air flow prior to re-connecting the equipment to a power supply. NOTE 2 Guidance should be sought from IEC 60068-3-4 when deciding upon the damp heat test to be applied. NOTE 3 The manufacturer should declare the number of binary input circuits and output devices energized during the test.	

6.12.3.7 Cyclic temperature with humidity test

The cyclic temperature with humidity test shall be performed to prove the resistance of the equipment to exposure to high humidity condensing atmospheres. See Table 9.

Table 9 – Cyclic temperature with humidity test

Subject	Test conditions
Test reference	Test Db: IEC 60068-2-30:2005
Preconditioning	1 Stabilized in test chamber at 25 °C ± 3 °C, 60 % ± 10 % relative humidity. 2 After stabilization the relative humidity shall be increased to 95 % or greater within 1 h, whilst maintaining the same temperature
Initial measurement	According to 6.12.2
Conditions	During the test, the equipment shall be continuously energized and maintained in the in-service condition, with any influencing quantity set to its reference condition
Temperature	Lower temperature cycle 25 °C ± 3 °C; Upper temperature cycle: equipment specified for indoor use: 40 °C ± 2 °C; Equipment specified for outdoor use: 55 °C ± 2 °C; Test cycle, including ramp up and down as per IEC 60068-2-30, Figure 2a or 2b
Humidity	97 %, –2 % +3 %, at lower temperature; 93 % ± 3 % at upper temperature; Test cycle, including ramp up and down as per IEC 60068-2-30 Figure 2a or 2b
Duration of exposure	6 of 24 h (12 h + 12 h) cycles
Measuring and/or loading	Equipment loaded according to 6.12.2
Recovery procedure: - time - climatic conditions - power supply	See Clause 9 of IEC 60068-2-30 1 h minimum to 2 h maximum, all tests to be conducted during that period. Standard reference conditions as stated in Table 10. Equipment energized
Final measurements	According to 6.12.2
NOTE The manufacturer should declare the number of binary input circuits, and output relays energized and carrying maximum rated current, during the test.	

6.13 Mechanical requirements

6.13.1 Vibration response and endurance (sinusoidal)

The EUT shall meet the requirements of IEC 60255-21-1. The test severity class shall be selected from either Table 1 or Table 2 of this standard to withstand the mechanical vibrations likely to be experienced in a particular transportation or type of use. The manufacturer shall declare the class selected.

NOTE Annex A gives guidance on test settings.

6.13.2 Shock response, shock withstand and bump

The EUT shall meet the requirements of IEC 60255-21-2. The test severity class shall be selected from either Table 1 or Table 2 of this standard to withstand the mechanical shocks and bumps likely to be experienced in a particular transportation or type of use. The manufacturer shall declare the class selected.

NOTE Annex A gives guidance on test settings.

6.13.3 Seismic

The EUT shall meet the requirements of IEC 60255-21-3. The test severity class shall be selected from either Table 1 or Table 2 to withstand the mechanical stresses likely to be experienced in seismic areas. The manufacturer shall declare the class selected.

NOTE Annex A gives guidance on test settings.

6.14 Pollution

If the EUT is operated within an environment outside the pollution limits defined by Table 1 and Table 2, then measures shall be taken by the equipment user to protect the equipment against these conditions.

6.15 Electromagnetic compatibility (EMC)

The equipment shall comply with the requirements of IEC 60255-26.

NOTE Annex A gives guidance on test settings.

7 Tests

7.1 General

All intrinsic accuracy testing shall be performed with test equipment that has accuracy better than that claimed by the EUT. The actual measurement errors of the EUT shall be less than or equal to the declared value of error taking into account the test equipment measurement uncertainty. The test equipment shall be calibrated to international traceable standards.

7.2 Test reference conditions

Unless otherwise specified, all tests shall be carried out under the conditions stated in Table 10.

Table 10 – Test reference conditions

Influence quantity	Reference conditions
Operating temperature	20 °C ± 5 °C
Relative humidity	45 % to 75 % RH
Atmospheric pressure	86 kPa to 106 kPa
Auxiliary supply voltage	Rated power supply voltage ±1 %
Residual voltage [a]	≤1,0 %
External continuous magnetic field	Induction equal to or less than 0,5 mT
D.c. component on a.c. voltage and current	As specified in lower level documents
Alternating component in d.c. auxiliary energizing quantities	Peak-ripple factor of 0 % to 15 % of rated d.c. values in accordance with IEC 60255-11.
Waveform	Sinusoidal, distortion factor 5% [b]
Frequency	Rated frequency (50 Hz or 60 Hz) ±0,2 %

[a] The vector sum, in a multi-phase system, of all the line-to-earth voltages.

[b] Distortion factor: ratio of the harmonic content obtained by subtracting the fundamental wave from a non-sinusoidal harmonic quantity and the r.m.s. value of the non-sinusoidal quantity. It is usually expressed as a percentage.

7.3 Test overview

The type testing shall be used to verify the new hardware/software designs against the product specification and standards. Once a product has been type tested it shall not be necessary to repeat the testing provided the design does not alter. Should a design change occur then a risk assessment shall be performed and documented to determine which type tests are still valid and which tests need to be repeated.

Type testing a product which is part of a product family shall be considered sufficient to cover the entire product family provided a documented risk assessment is carried out to determine which type tests are valid and which tests need to be repeated on the rest of the product family.

During the application of the EMC/mechanical/environmental tests, the equipment shall be in the state specified in the EMC, mechanical and/or environmental standards. The quiescent state for a protective relay shall be the energizing quantities applied at rated values and the protection functions set such that the threshold of operation is within twice their accuracy tolerance, e.g. overcurrent protection function with a tolerance of 5 % and a setting of 1 A should be injected with 0,9 A. Additional guidance is given in Annex A.

Type tests and routine tests shall be carried out according to Table 11.

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Table 11 – Test overview

No.	Test items	Type test	Routine test	Standard	Subclause
1	Dimensions of structure and visual inspection	√	√	IEC 60297-3-101	6.1, 6.2
2	Functional requirements: – Steady-state simulation – Dynamic simulation	√	√[a]	Relevant IEC 60255-100 series	6.5, 6.7, 6.8
3	Product safety requirements [c] (including thermal short time rating)	√	√[b]	IEC 60255-27	6.4
4	EMC requirements: – Emission – Immunity	√		IEC 60255-26	6.15
5	Energizing quantities: – Burden – Change of auxiliary energizing quantity	√		N/A IEC 60255-11	6.10 6.9
6	Contact performance	√		N/A	6.11
7	Communication requirements	√		Relevant IEC protocol standards	6.6
8	Climatic environmental requirements: – Cold – Dry heat – Change of temperature – Damp heat	√		IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27	6.12
9	Mechanical requirements: – Shock – Vibration – Bump – Seismic	√		IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3	6.13
10	Enclosure protection	√		IEC 60529, IEC 60255-27	6.3

NOTE The symbol √ means that the test is mandatory.

[a] Depending upon the operation of the equipment, the manufacturer shall set up the appropriate testing process in order to guarantee the accuracy of the characteristic quantities and operate time of the relays.

[b] Only test for dielectric and protective bonding continuity, see IEC 60255-27.

[c] The product safety requirements include the dielectric tests and thermal short-time rating.

7.4 Type test report content

A test report giving the test procedures and results shall always be produced.

The test report shall include at least the following basic information:

a) a title (e.g. “test report”);

b) the name(s), function(s) and signature(s) or equivalent identification of person(s) authorizing the test report;

c) the name and address of the laboratory, and the location where the tests were carried out, If different from the address of the laboratory;

d) table of contents;

e) unique identification of the test report (such as the serial number), and on each page an identification in order to ensure that the page is recognized as a part of the test report and a clear identification of the end of the test report;

f) the name and address of the client (where applicable);

g) a description of, the condition of, and unambiguous identification of the equipment;

h) the date(s) of performance of the test;

i) a statement of what tests were performed and to what international standards, including the dates;

j) the acceptance criteria used;

k) the tools and instrumentation used;

l) the test conditions;

m) the test results with, where appropriate, the units of measurement;

n) where relevant, a statement to the effect that the results relate only to the equipment tested and possibly a product family.

In addition to the above basic information, test reports shall include the following information:

o) the test method and procedures;

p) the test conclusion(pass/fail);

q) where appropriate and needed, opinions and interpretations;

r) if required, the test report shall be in accordance with that given in the relevant IEC 60255 series (e.g. the IEC 60255-22 series, and IEC 60255-25).

8 Marking, labelling and packaging

The equipment should be marked and labelled in accordance with the requirements of IEC 60255-27.

The manufacturer shall ensure that the equipment is suitably packaged to withstand, without damage, reasonable handling and environmental conditions appropriate to the method(s) of transportation to the user's delivery address. The user shall visually inspect the equipment to ensure that it has not been damaged during transportation.

9 Rules for transport, storage, installation, operation and maintenance

The equipment should be stored and transported within the packaging materials supplied with the product and shall be installed in accordance with instructions given by the manufacturer.

10 Product documentation

Product documentation provided by the manufacturer shall specify instructions for transport, storage, installation, operation and maintenance.

The following are the most important points to be considered in the instructions to be provided by the manufacturer:

- detailed description of each protection function and its theory of operation;

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- list of available settings and an explanation for each setting;
- product application guidelines;
- full technical data including environmental conditions;
- product safety instructions;
- conditions during transport, storage and installation;
- unpacking and lifting;
- assembly;
- mounting;
- connections;
- documentation relating to communications protocols;
- final installation inspection;
- commissioning;
- maintenance;
- failure reporting.

NOTE The product safety instructions should be included with the equipment in paper format. All other information can be supplied in electronic format, i.e. CDROM.

Annex A
(informative)

Type testing guidelines

A.1 General

EMC, mechanical and environmental testing requires the EUT to be in a various states defined in the various lower level standards. Measuring relays and protection equipment have many different types of input/output ports, including current and voltage inputs, whose measured values can be used by protection functions. Due to the complexity of modern software-based protection, these functions can have a large number of settings, making testing with all possible settings very difficult.

This informative annex does not aim at addressing every specific case, but aims at giving testing guidelines for verifying the basic protection functions. These guidelines have to be adapted to each function. For instance, distance protection functions, differential protection functions or generator protection functions are not covered by this annex.

A.2 Testing guidelines

A.2.1 Introductory remark

It is the manufacturer's responsibility to perform tests that cover the specified range of settings relevant to the particular product in order to verify the correct operation of the equipment.

The following guidance aims at helping designers during design phase and/or type testing. Guidance specified in relevant lower level standards shall be used where available.

These guidelines are for EMC, mechanical and environmental testing but can be applied to other tests.

A.2.2 Typical test point(s) for each measuring input

A typical test point is a specific value in a range that is used (possibly in conjunction with other typical test points) to check the compliance of a product for the full range of operation.

For each measuring input, the most sensitive setting(s) in the range should be looked for by the manufacturer. Usually, the lowest value in the range, or the value corresponding to an amplifier gain change, may be the most sensitive setting according to disturbances.

These sensitive points should be used as typical test points.

A.2.3 Activated protection functions

Integrated protection relays should have each measuring input used by at least two protection functions:

– one using an overcurrent or overvoltage protection function; and
– one using an undercurrent or undervoltage protection function.

It is the responsibility of the manufacturer to choose the relevant functions.

A table such as Table 1 should be filled in and documented in the type test report.

Table A.1 – Example of protection functions that may be used during tests

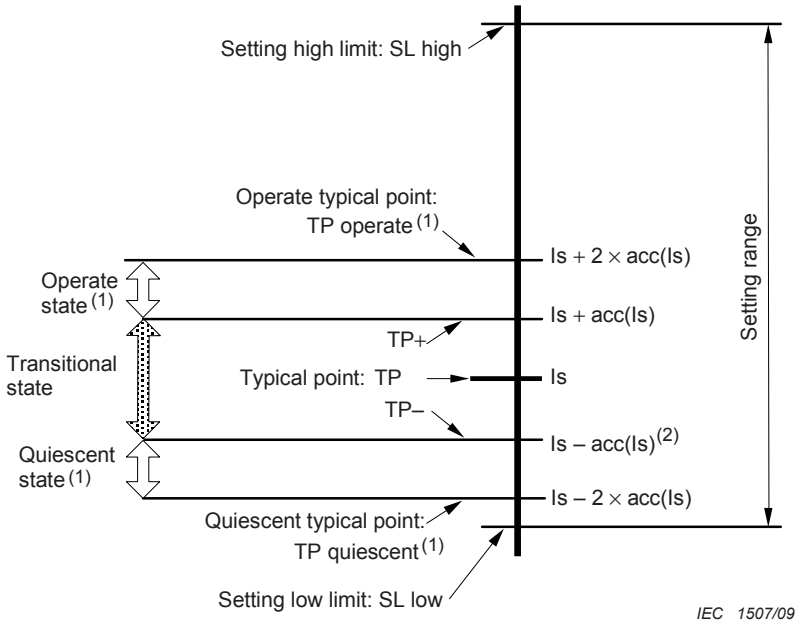
Isolated measuring input	Overcurrent or overvoltage protection functions	Undercurrent or undervoltage protection functions
Current input	Phase overcurrent protection	Phase undercurrent protection
Residual current input	Earth fault	---
Voltage input	Phase overvoltage protection	Phase undervoltage protection
Residual voltage input	Neutral voltage displacement	---

A.2.4 Test values

The typical test points should be used. For each typical test point, the tests should be carried out with input energizing quantities applied to the appropriate circuits. The values of the input energizing quantities may be within twice the assigned accuracy of the transitional state below and above the operate value, see Table A.2. The auxiliary energizing supply shall be equal to the rated value, where applicable.

A.2.5 Time delay

Time delay settings of the equipment should be set to the minimum practical values as defined by their intended application.



Key
(1) This figure is valid for example for overcurrent or overvoltage protections. For undercurrent or undervoltage protections, replace “operate” by “quiescent” and vice versa.

(2) acc(Is) = accuracy at Is value, e.g. acc(Is) = 5 % at Is = A. In this case, TP = 1 A; TP+ = 1,05 A; TP– = 0,95 A; TP operate = 1,1 A; TP quiescent = 0,9 A.

Figure A.1 – Definition of operate, transitional and quiescent states

NOTE Where the accuracy of the element under test is small then the hysteresis of the element should also be taken into account.

Table A.2 – Example of EMC test conditions for measuring inputs

	For transient EM phenomena: 1 MHz burst, ESD, fast transient burst and surges	For permanent EM phenomena: radiated EM field and conducted disturbances
Quiescent state (see Figure 1)	Select values for the measuring inputs so that the equipment is at "TP quiescent". Then perform the EMC tests, and check that no trip signal is issued.[c]	Select values for the measuring inputs so that the equipment is at "TP quiescent". Then perform the EMC tests, and check that no trip signal is issued.[c]
Operate state (see Figure 1)	Adjust the values for the measuring inputs so that the equipment changes from "TP quiescent" to "TP operate", and verify that the trip signal is issued. [a, b, c] Then perform the EMC tests, and check that the trip signal is held during the application of the tests.[a, b, d]	For each spot frequency specified, alter the values for the measuring inputs so that the equipment changes from the "TP quiescent" to the "TP operate". Then verify that the trip signal is issued and held during the application of this test.[c]

[a] Not mandatory for ESD test, see IEC 60255-22-2.

[b] Not mandatory for surge test, see IEC 60255-22-5.

[c] This requirement is for time delayed trip signals, not instantaneous trips.

[d] Some devices have a blocking logic, which will cause the relay to reset trip signal after time delay when the current is hold on. In this case, the test duration should be shorter than this blocking time delay.

Annex B
(informative)

Intrinsic, operating and overall system accuracy

B.1 General

The relationship between intrinsic, operating and overall system accuracy are shown graphically in Figure B.1.

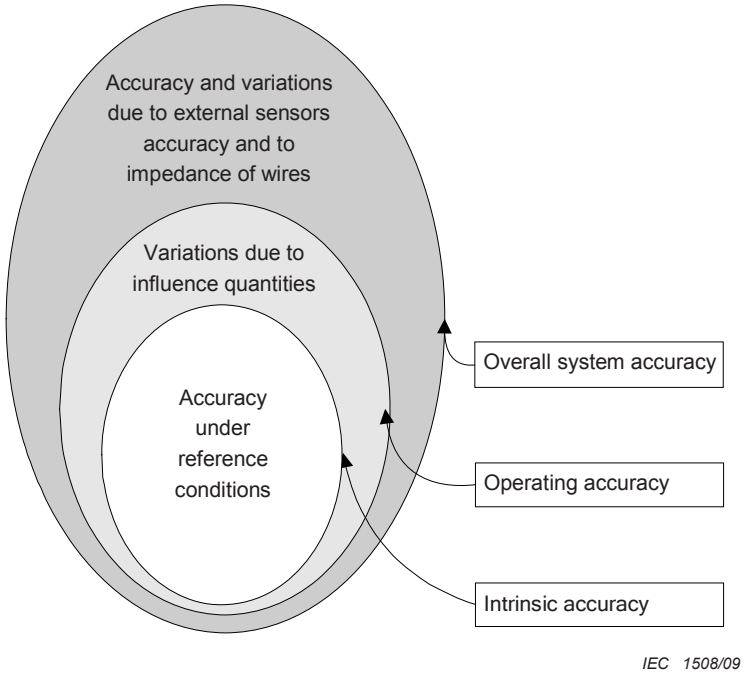


Figure B.1 – Different kind of accuracies

B.2 Intrinsic accuracy

Intrinsic accuracy includes instrument uncertainty under reference conditions.

B.3 Operating accuracy

Operating accuracy includes intrinsic accuracy and variations due to influence quantities. The additional variations should be stated for each influencing quantity.

B.4 Overall system accuracy

Overall system accuracy includes operating accuracy and variation due to impedance of wires and variations due to sensors accuracy.

B.5 Example

Let us consider the current measurement function of a protection equipment, measuring a current from 0,1 I_n to 20 I_n, with I_n = 100 A.

a) The first test will be carried out under reference conditions, e.g. at 23 °C ± 2 °C, with 40 % to 60 % RH, a sinusoidal waveform at 50 Hz (or 60 Hz) ± 0,2 %, with no voltage unbalance and no external EMC influencing factors. Let us assume that on the whole measuring range (0,1 I_n to 20 I_n), at worst the function will measure 998 A instead of the 1 000 A injected current. The intrinsic uncertainty is 2 A out of 1 000 A, meaning 0,2 % intrinsic accuracy. The following tests will be carried out for instance at I_n (100 A). Let us assume that under reference conditions the measured current is 99,8 A.

b) The second test will be carried out under reference conditions excluding temperature. Let us assume that on the whole temperature range (e.g. –25 °C to +70 °C), at worst the function will measure 99,7 A instead of the 99,8 A previously measured. The variation due to temperature influence is then 0,1 A out of 99,8 A, meaning a 0,1% deviation.

c) The third test will be carried out under reference conditions excluding frequency. Let us assume that on the whole frequency range (e.g. –5 % to +5 %), at worst the function will measure 99,825 A instead of the 99,8 A previously measured. The variation due to frequency influence is then 0,025 A out of 99,8 A meaning a 0,025 % deviation.

d) The fourth test will be carried out under reference conditions including harmonics. Let us assume that on the whole harmonics range (e.g. 10 % with 3rd harmonic, 12 % with 5th harmonic, …) at worst the function will measure 99,805 A instead of the 99,8 A previously measured. The variation due to harmonics influence is then 0,005 A out of 99,8 A, meaning a 0,005 % deviation.

It is then possible to calculate operational accuracy with the following formula:

$$\text{Operating accuracy} = \left|\text{Intrinsic accuracy}\right| + 1{,}15 \times \sqrt{\sum_{i=1}^{N} (\text{variation due to influence quantities})^2}$$

$$\text{Operating accuracy} = \left|0{,}2\right| + 1{,}15 \times \sqrt{0{,}1^2 + 0{,}025^2 + 0{,}005^2} = 0{,}32\ \%$$

It is then possible to calculate overall system accuracy (assuming the current sensor is a class 0,5 sensor and assuming there are short wires) with the following formula:

$$\text{Overall system accuracy} = 1{,}15 \times \sqrt{(\text{operating accuracy})^2 + \sum_{i=1}^{N} (\text{sensor/wiring accuracy})^2}$$

$$\text{Overall system accuracy} = 1{,}15 \times \sqrt{(0{,}32)^2 + (0{,}5)^2} = 0{,}68\ \%$$

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Annex C
(informative)

Guidance on dependability

C.1 Overview

Figure C.1 gives an overview of the fields that may be of interest for protection relays.

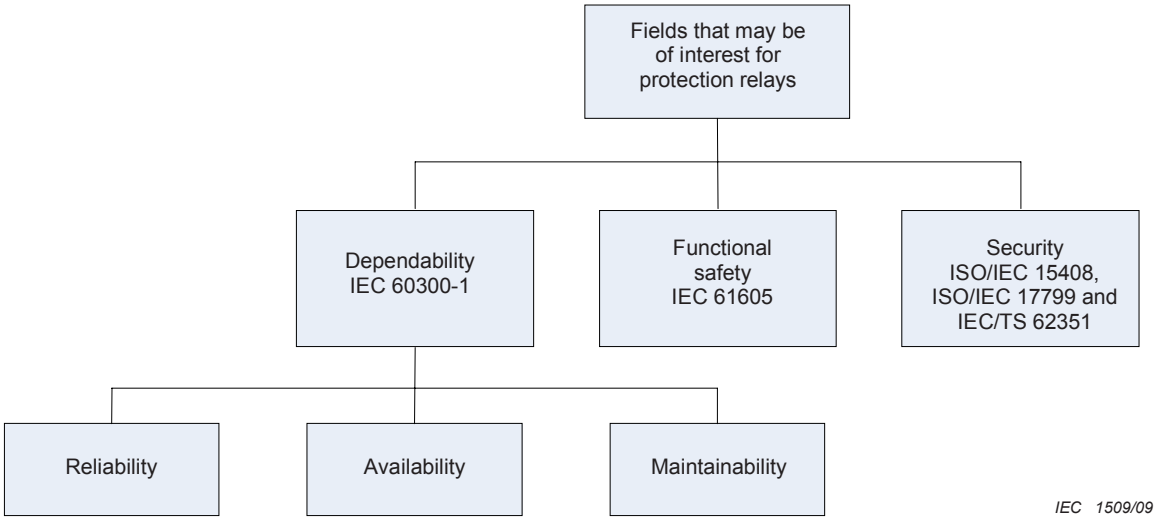

Figure C.1 – Overview of fields that may be of interest for protection relays

C.2 Functional safety and security aspects

Functional safety aspects should be considered, e.g. IEC 61508 [3] and ISO/IEC Guide 51[4].

For security aspects ISO/IEC 17799 [5] and the ISO/IEC 15408[6] and IEC/TS 62351[7] series apply.

NOTE The concept of security differs from the one given in IEC 60050-448[8].

C.3 Parameters to measure

The following scheme explains the different phases between failures:

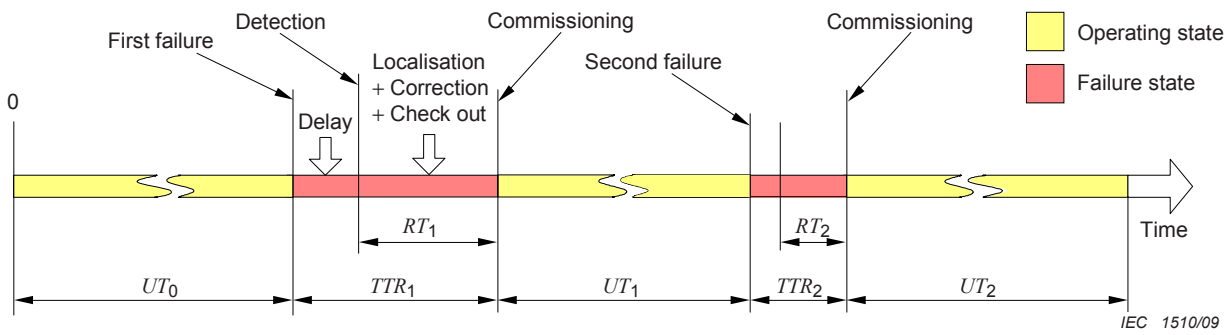

Figure C.2 – Failure detection chart

Table C.1 – Definitions of symbols

IEC 60050-191 reference	Definition	Symbol
IEV 191-09-11	Up time	UT
IEV 191-09-08	Down time[a]	DT
IEV 191-08-16	Repair time	RT
IEV 191-07-25	Recovery	---
---	Time to recovery	TTR
[a] Down time includes both corrective maintenance (TTR) and preventative maintenance.		

Table C.2 – Meaning of terms defined in IEC 60050-191 for protection relays

IEC 60050-191 reference	Definition	Meaning
191-12-06	Mean time to first failure	$MTTFF = UT_0$
191-12-07	Mean time to failure	$MTTF = \frac{\sum_{0}^{n} UT_i}{n+1}$
191-12-08	Mean time between failures	$\text{Mean time between failures} = \frac{\sum_{1}^{n} UT_i + TTR_i}{n}$
191-12-09	Mean operating time between failures	$MTBF = \frac{\sum_{1}^{n} UT_i}{n}$
191-11-11	Mean up time	$MUT = \frac{\sum_{0}^{n} UT_i}{n+1}$
191-11-12	Mean down time	$MDT = \frac{\sum_{1}^{n} DT_i}{n}$

IEC 60050-191 reference	Definition	Meaning
191-13-08	Mean time to recovery	$MTTR = \frac{\sum_{1}^{n} TTR_i}{n}$
191-13-05	Mean repair time	$MRT = \frac{\sum_{1}^{n} RT_i}{n}$
NOTE 1 Down time includes both corrective maintenance (TTR) and preventive maintenance. Therefore, MDT is different from MTTR and MUT is different from MTBF. NOTE 2 For non repairable equipment, MTTF and MTTFF are the same.		

Bibliography

[1] IEEE Std C37.118:1995, *IEEE standard for synchrophasors for power systems*

[2] IEEE Std C37.2:1996, *IEEE standard electrical power system device function numbers and contact designations*

[3] IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

[4] ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

[5] ISO/IEC 17799, *Information technology – Security techniques – Code of practice for information security management*

[6] ISO/IEC 15408 (all parts), *Information technology – Security techniques – Evaluation criteria for IT security*

[7] IEC/TS 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

[8] IEC 60050-448*, International Electrotechnical Vocabulary – Chapter 448: Power system protection*

[9] IEC 60255-5:2000, *Electrical relays – Part 5: Insulation coordination for measuring relays and protection equipment – Requirements and tests*

[10] IEC 60300-1, *Dependability management – Part 1: Dependability management systems*

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