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INTERNATIONAL STANDARD

colour inside

Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures –
Part 6: Effectiveness of residual current devices (RCD) in TT, TN and IT systems

IEC 61557-6:2019-07 RLV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

Part 6: Effectiveness of residual current devices (RCD) in TT, TN and IT systems

FOREWORD

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International Standard IEC 61557-6 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This third edition cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of requirements for testing a new type of RCD;
b) addition of requirements for type B RCDs (former Annex B);
c) addition of new Annex B on recommended tripping times;
d) alignment of the structure with that of the whole IEC 61557 series.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
85/ 684/FDIS	85/ 697/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

This International Standard is to be used in conjunction with IEC 61557-1:2019.

A list of all parts in the IEC 61557 series, published under the general title *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

Part 6: Effectiveness of residual current devices (RCD) in TT, TN and IT systems

1 Scope

~~This part of IEC 61557 specifies the requirements for measuring equipment applied to the testing of the effectiveness of protective measures by regular disconnections of residual current protective devices (RCD) in TT, TN and IT systems.~~

This part of IEC 61557 specifies the requirements applicable to measuring equipment for testing the effectiveness of protective measures of residual current devices (RCD) installed in TT, TN and IT systems.

It is not the purpose of this document to verify the RCD according to their product standards.

NOTE Applicable tripping tests for time and current of RCD are listed in Annex A, Table A.1.

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/TR 60755, *General requirements for residual current operated protective devices*~~

~~IEC 60947-2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*~~

~~IEC 61008 (all parts), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*~~

~~IEC 61009 (all parts), *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*~~

IEC 61010-1:~~2001~~2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*
IEC 61010-1:2010/AMD1:2016[1]

IEC 61010-2-030:2017, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for equipment having testing or measuring circuits*

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

[1] A consolidated version of this publication exists, comprising IEC 61010-1:2010 and IEC 61010-1:2010/AMD1:2016.

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IEC 61557-1:~~2007~~2019, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61557-1 and the following 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
earth fault current
~~I_Δ~~
current flowing to earth due to an insulation fault

[SOURCE: IEC 60050-442:1998, 442-01-23]

3.2
residual current
I_Δ
RMS value of the vector sum of the currents flowing through the main circuit of the residual current device

[SOURCE: IEC 60050-442:1998, 442-05-19, modified – in alignment with the use in this document. The symbol has been modified.]

3.3
rated residual operating current
$I_{\Delta n}$
fault current for which the residual current ~~protective device~~ is designed

3.4
residual operating current
I_a
~~fault current at which the residual current protective device is activated~~
value of residual current which causes the residual current device to operate under specified conditions

[SOURCE: IEC 60050-442:1998, 442-05-20, modified – The symbol has been added.]

~~**3.5**~~
~~**total earthing resistance**~~
~~R_A~~
~~resistance between the main earthing terminal and the earth~~

~~[IEV 826-04-03[2)]]~~

~~[2)] IEC 60050-826:1982, *International Electrotechnical Vocabulary – Part 826: Electrical installations of buildings* (withdrawn and superseded by IEC 60050-826:2004, *International Electrotechnical Vocabulary – Part 826: Electrical installations*, in which this definition no longer appears).~~

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3.5
leakage current
electric current in an unwanted conductive path to earth under normal operating conditions

[SOURCE: IEC 60050-195:1998, 195-05-15, modified – "to earth" has been added and the deprecated term "earth current" omitted.]

3.6
test resistance
R_p
resistance by means of which a fault current for test purposes is produced

3.7
resistance to earth
resistance to ground, US
real part of the impedance to earth

[SOURCE: IEC 60050-195:1998, 195-01-18]

4 Requirements

~~The following requirements as well as those given in IEC 61557-1 shall apply.~~

4.1 General

In addition to the requirements of IEC 61557-1:2019, Clause 4, the requirements of Clause 4 of this document shall apply.

Test leads and test probes used with this measuring equipment shall fulfil the requirements of IEC 61010-031.

Equipment intended for making measurements on distribution systems shall, at the minimum, be rated for measurement category III in accordance with IEC 61010-2-030.

Equipment intended for making measurements on electrical equipment shall, at the minimum, be rated for measurement category II in accordance with IEC 61010-2-030.

4.2 ~~Tests~~ Functions

4.2.1 ~~Tripping tests~~ Measurement of trip current

The measuring equipment shall be capable of indicating ~~that~~ if and when the residual operating current of the protective device is less than or equal to the rated residual operating current.

The tests shall be carried out with a sinusoidal, or mains-derived quasi sinusoidal test current.

The operating uncertainty of the ~~calibrated~~ test currents, determined in accordance with Table 1, shall not exceed ~~0 % to +10 % of the rated residual current with the rated residual operating current as fiducial value determined in accordance with Table 1~~ (the rated residual operating current) +10 %.

The operating uncertainty of measurement of the residual operating current, determined in accordance with Table 1, shall not exceed ±10 % of the rated residual operating current ~~as fiducial value determined in accordance with Table 1~~.

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If the measuring equipment is provided for the purpose of testing residual current ~~protective~~ devices (RCD) of 30 mA or below, installed for supplementary protection, the measuring equipment shall be capable of providing a test of 5 times the rated residual operating current. The test period shall be limited to 40 ms. When measuring the trip time, this limit of test period need not be applied so long as the fault voltage remains below the touch voltage limit.

If the measuring equipment is capable of producing half-wave test currents, ~~testing of residual current protective devices (RCDs) Type A may alternatively be carried out using half-wave test currents according to the IEC 61008 and IEC 61009 series, IEC 60947-2 and IEC/TR 60755~~ testing of pulse current sensitive RCDs may alternatively be carried out using half-wave test currents. In this case, test equipment shall be able to test in both polarities.

If the measuring equipment includes a test intended to be applied to residual current devices (RCD) type B, the test current shall be an increasing smooth direct residual current.

NOTE A smooth direct current is a current with less than 10 % AC ripple (peak to peak).

If the test current increases linearly, the rate of increase shall not be greater than 2 times $I_{\Delta n}$ in 5 s. If the test current increases in steps, the increase per step shall not be more than 2 times $I_{\Delta n}/30$ and the rate of increase shall not be greater than 2 times $I_{\Delta n}$ in 5 s.

It shall be possible to test with both polarities of the test current. The operating uncertainty of the measurement of the residual current shall not exceed ±10 % of the rated residual operating current and the operating uncertainty of the maximum value of the increasing test current shall not exceed (2 times the rated residual operating current) +10 %.

4.2.2 Non-tripping ~~tests~~ functions

When a test at 50 % or less of the rated residual operating current is included to test the ~~reliability~~ immunity of the RCD to nuisance tripping, the minimum test period for general type RCDs shall be 0,3 s and for type S RCDs, it shall be 0,5 s. The protective device shall not ~~open~~ operate.

When a non-trip test at 50 % or less of the rated residual operating current is included, the operating uncertainty of the calibrated test current shall ~~not exceed~~ be in the range between 0 % and −10 % of the specified non-tripping test current in accordance with Table 1.

~~NOTE~~ If the purpose of the test is to evaluate other parameters (e.g. fault voltage) the minimum test period may be shorter but not less than one cycle of the rated frequency.

4.2.3 Fault voltage indication

The measuring equipment shall be capable of indicating whether the fault voltage at the rated residual operating current of the protective device is less than or equal to the conventional touch voltage limit. The test may be carried out with or without a probe.

~~NOTE~~ Indication ~~can~~ may be provided by displaying the value of the fault voltage or by the use of other clear indicators.

~~**4.2.1** If a fault voltage is displayed or indicated for the residual operating current and not for the rated residual current, this shall be indicated in the display or on the measuring equipment, or calculated according to the following formulae.~~

~~The following condition shall be fulfilled:~~

$$\cancel{U_F \leq U_L * \frac{I_\Delta}{I_{\Delta N}}}$$

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~~where~~

~~U_L is the conventional touch voltage limit.~~

~~**4.2.2** The operating uncertainty during the measurement of the fault voltage shall not exceed 0 % to +20 % with the conventional touch voltage limit as fiducial value, determined in accordance with Table 1.~~

~~NOTE The internal resistance of the voltage measuring equipment should be at least 0,7 kΩ/V of the full-scale value of the measurement range. The influence of the voltage measurement on the measurement of the fault current should be taken into consideration.~~

~~**4.3** The measuring equipment shall be capable of measuring the trip time of residual current protective devices at the rated residual operating current or shall be capable of indicating the compliance with the maximum allowed trip time.~~

~~When measuring the trip time, the operating uncertainty shall not exceed ± 10 % with the maximum permissible trip time as fiducial value and the influence quantities according to Table 1.~~

~~**4.4** On measuring equipment with indicators, the switching value of the indicators shall be the conventional true value for the calculation of uncertainties, provided nothing to the contrary is stated.~~

~~**4.5** The operating uncertainty applies under the rated operating conditions stated in IEC 61557-1 and the following:~~

- ~~the protective conductor is free from extraneous voltages;~~
- ~~the system voltage remains constant during the measurement;~~
- ~~the circuit following the residual current protective device carries no leakage current;~~
- ~~the system voltage is within 85 % to 110 % of the nominal system voltage for which the equipment has been designed;~~
- ~~the resistance of the probes is within the limits stated by the manufacturer;~~
- ~~sinusoidal test current.~~

If the value of the fault voltage or the indication for the fault current (shown on a display or otherwise indicated) show the value for the residual current and not for the rated residual operating current, this shall be indicated on the display or on the measuring equipment. Otherwise the fault voltage shall be calculated according to Equation 1:

$$U_F \leq U_L \times \frac{I_a}{I_{\Delta n}} \quad (1)$$

where

U_F is the fault voltage;

U_L is the conventional touch voltage limit;

$I_{\Delta n}$ is the rated residual operating current;

I_a is the residual operating current.

The operating uncertainty of the fault voltage measurement, determined in accordance with Table 1, shall be in the range of 0 % and +20 % with the conventional touch voltage limit as fiducial value.

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The internal resistance of the voltage measuring equipment should be at least 0,7 kΩ/V of the full-scale value of the measurement range. The influence of the voltage measurement on the measurement of the fault current should be taken into consideration.

4.2.4 Measurement of trip time

The measuring equipment shall be capable of measuring the trip time of residual current devices (RCD) at the rated residual operating current or shall be capable of indicating the compliance with the maximum permissible trip time. As a minimum, the test equipment shall include a test with a sinusoidal test current.

When measuring the trip time, the operating uncertainty shall not exceed ±10 % with the maximum permissible trip time as fiducial value and the influence quantities according to Table 1.

If trip times are measured with different waveforms, the manufacturer should provide guidance on the interpretation of the results in the operating instructions.

4.3 Measurement with indicators

On measuring equipment with indicators, the threshold value of the indicators shall be the value for the calculation of uncertainties.

4.4 Test with rated residual operating current

When testing with the rated residual operating current, the following conditions shall be met:

– the test current shall be switched on during a zero crossing;
– the starting phase of the test current shall be indicated to the user;
– the test period shall be limited to the maximum allowed trip time of the residual current ~~protective~~ device (RCD) under test. When measuring the trip time, these limits of the test periods need not be applied.

4.5 Fault voltages exceeding U_L

Prevention of danger ~~by~~ due to fault voltages exceeding ~~50 V~~ U_L within the system under test shall be ensured during measurements. This can be achieved as follows:

– automatic disconnection in accordance with IEC 61010-1:2010/AMD1:2016, Figure ~~1~~2, when fault voltages ~~with a magnitude >50 V~~ > U_L occur;
– use of test resistances R_p adjustable in steps, or continuously, in such a manner that the test is started with a resistance that permits a maximum current of 3,5 mA to flow when all parallel-connected circuits are included. An unambiguous detection shall be ensured, for example by means of a voltmeter, ~~as~~ to determine whether this test resistance can be varied without producing a hazardous fault voltage.

If the measuring equipment indicates the value of the voltage at its measuring terminals, it shall also indicate if the system voltage exists and if the live conductor is exchanged with the protective conductor.

4.6 Overvoltage

The user shall not be exposed to danger and the equipment shall not be damaged when the measuring equipment is connected for at least 10 min to 120 % of the nominal voltage of the distribution system for which the measuring equipment has been designed. Protective devices shall not be activated.

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The user shall not be exposed to danger and the measuring equipment shall not be damaged when the measuring equipment is accidentally connected for at least 1 min with up to 173 % of its rated voltage to earth. Protective devices may be activated.

5 Marking and operating instructions

5.1 Marking

In addition to ~~the marking in accordance with~~ IEC 61557-1:2019, 5.1 and 5.2, the following information shall be provided on the measuring equipment.

The rated residual operating current or rated residual operating currents of the residual current device (RCD) for which the measuring equipment has been designed shall be marked.

The maximum voltage to earth and the rated measuring category shall be marked.

5.2 Explicit indication of the waveform of the testing current

The measuring equipment shall contain the indication that in the case of a half wave testing current or DC testing current, the tripping test shall be carried out in both directions (see Annex A for tripping test for different types of RCD). Where there is insufficient space, the warning symbol according to IEC 61010-1:2010, Table 1 symbol 14 shall be marked adjacent to the RCD function or a warning shall be given on the display.

5.3 Operating instructions

In addition to IEC 61557-1:2019, 5.3, the operating instructions shall ~~state~~ include the following information.

– Where the measuring circuit has no probe and ~~if~~ a ~~possible~~ voltage present between the protective conductor and earth will influence the measurements, a warning ~~must~~ shall be included.
– Where the measuring circuit uses the N-conductor as a probe, a warning shall be given to test the connection between the neutral point of the distribution system and earth before the test is started; a possible voltage between the N-conductor and the earth may influence the measurements.
– A warning that leakage currents in the circuit following the residual current ~~protection~~ device (RCD) may influence the measurements.
– Where the fault voltage is indicated by the test equipment, a clear statement shall be given as to whether the voltage relates to the rated residual operating current or to the residual operating current of the protective device. If applicable, a note to fulfil the conditions of 4.2.3 shall also be included.
– A statement that the earth electrode resistance of a measuring circuit with a probe shall not exceed a value to be stated by the manufacturer.
– A warning, that when using a probe, the potential fields of other earthing installations may influence the measurement.
– A warning that special conditions in residual current ~~protective~~ devices (RCD) of a particular design, for example of type S (selective and ~~resistance~~ resistant to impulse currents) shall be taken into consideration.
– A warning that equipment ~~, which is connected downstream of a~~ in the circuit following the residual current ~~protective~~ device (RCD) may cause a considerable extension of the operating time. Examples of such equipment might be connected capacitors or running motors.

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6 Tests

~~The following tests in addition to those required according to IEC 61557-1 shall be executed.~~

6.1 General

In addition to IEC 61557-1:2019, Clause 6, the tests in Clause 6 of this document shall be performed.

These tests shall be ~~carried out~~ performed at all rated residual operating currents and in addition at 50 % and 500 % of the rated residual operating current, if applicable.

The test circuit shall be adapted to test both at the limits of the fault voltage for which the equipment is designed and at the appropriate total earthing resistance $R_A = R_{Amax}$ for each range.

The test circuit shall be adapted to each test method employed. The manufacturer's data shall be ~~heeded~~ observed.

NOTE The maximum earthing resistance is derived from:

$$R_{A_{max}} = \frac{U_L}{I_{\Delta n}}$$

where

U_L is the conventional touch voltage limit;

$I_{\Delta n}$ is the rated residual operating current.

6.2 Operating uncertainty

The operating uncertainty applies under the rated operating conditions stated in IEC 61557-1 and the following:

– the voltage on the protective conductor relative to earth or N shall be below 1 V RMS;
– the system voltage remains stable within ±1 V during the measurement;
– the circuit following the residual current device (RCD) carries a negligible leakage current;
– the system voltage is within 85 % to 110 % of the nominal system voltage for which the equipment has been designed;
– the resistance of the probes is within the limits stated by the manufacturer.

The operating uncertainty shall be determined in accordance with Table 1. In this process, the intrinsic uncertainty shall be determined under the following reference conditions:

– nominal voltage of the distribution system;
– nominal frequency of the distribution system;
– reference temperature (23 ± 2) °C;
– reference position in accordance with the manufacturer's statement;
– protective conductor free from extraneous voltages;
– 100 Ω resistance of the auxiliary earth electrode in a TT system.

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Table 1 – Calculation of operating uncertainty

Intrinsic uncertainty or influence quantity	Reference conditions or specified operating range	Designation code	Requirements or test in accordance with the relevant parts of IEC 61557	Type of test
Intrinsic uncertainty	Reference conditions	A	~~Part 6, 6.1~~ IEC 61557-6:2019, 6.2	R
Position	Reference position ±90°	E_1	~~Part 1, 4.2~~ IEC 61557-1:2019, 4.2	R
Supply voltage	At the limits stated by the manufacturer	E_2	~~Part 1, 4.2, 4.3~~ IEC 61557-1:2019, 4.2, 4.3	R
Temperature	0 °C and 35 °C	E_3	~~Part 1, 4.2~~ IEC 61557-1:2019, 4.2	T
Resistance of the probes	Within the limits stated by the manufacturer	E_5	~~Part 6, 4.5~~ IEC 61557-6:2019, 6.3	T
System voltage	85 % to 110 % of the nominal voltage	E_8	~~Part 6, 4.5~~ IEC 61557-6:2019, 6.3	T
Operating uncertainty	$B = \pm\sqrt{A^2 + \frac{4}{3}\sum_i E_i^2}$		~~Part 6, 4.1~~ ~~Part 6, 4.2~~ ~~Part 6, 4.3~~ IEC 61557-6:2019, 6.2	R

Key

A = intrinsic uncertainty

~~E_n~~ E_i = variations

R = routine test

T = type test

F = fiducial value

$$B\,[\%] = \pm\frac{B}{F}\times 100\ \%$$

The operating uncertainty evaluated according to Table 1 shall not exceed the limits specified in 4.1, 4.2, 4.3 and 4.4.

6.3 Fault voltage

When measuring the fault voltage, compliance with the permissible operating uncertainty shall be tested for measurements with and without a probe.

Compliance with 4.5 shall be tested in all ranges.

Compliance with the conditions for the internal resistance in accordance with 4.2.3 shall be tested in all measurement ranges (type test).

6.4 Testing the connection to voltages higher than nominal voltage

Compliance with the requirements under ~~4.6 and 4.7~~ 4.5 shall be tested *(*routine test*)*.

~~**6.5** The overload protection in accordance with 4.8 and 4.9 shall be tested *(type test)*.~~

~~**6.6** Compliance with the tests in this clause shall be recorded.~~

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