BS IEC 62873-3-3:2016

BSI Standards Publication

Residual current operated circuit-breakers for household and similar use

Part 3-3: Specific requirements for RCDs with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

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National foreword

This British Standard is the UK implementation of IEC 62873-3-3:2016.

The UK participation in its preparation was entrusted by Technical Committee PEL/23, Electrical accessories, to Subcommittee PEL/23/1, Circuit breakers and similar equipment for household use.

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

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Residual current operated circuit-breakers for household and similar use – Part 3-3: Specific requirements for RCDs with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

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Part 3-3: Specific requirements for RCDs with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

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International Standard IEC 62873-3-3 has been prepared by subcommittee 23E: Circuit breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

The text of this standard is based on the following documents:

FDIS	Report on voting
23E/966/FDIS	23E/984/RVD

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

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

A list of all parts of the IEC 62873 series published under the general title *Residual current operated circuit-breakers for household and similar use* can be found on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

This document is part of the series described in the outline document IEC 62873-1.

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS FOR HOUSEHOLD AND SIMILAR USE –

Part 3-3: Specific requirements for RCDs with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

1 Scope

This part of IEC 62873 applies to RCDs equipped with screw-type terminals of copper – or of alloys containing at least 58 % of copper (if worked cold) or at least 50 % of copper (if worked otherwise), or of other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable – for use with untreated aluminium conductors, or with screw-type terminals of aluminium material for use with copper or aluminium conductors.

This part of IEC 62873 cannot be used alone but it is intended to be applied together with an RCD product standard (IEC 61008-1 or IEC 61009-1) if an RCD is equipped with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors.

In this part of IEC 62873, copper-clad and nickel-clad aluminium conductors are considered as aluminium conductors.

NOTE In AT, AU and DE, the use of aluminium screw-type terminals for use with copper conductors is not allowed.

– In AT and DE, terminals for aluminium conductors only are not allowed;

– In ES, the use of aluminium conductors is not allowed for final circuits in household and similar installations e.g. offices, shops;

– In DK, the minimum cross-sectional area for aluminium conductors is 16 mm^2.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61008-1*, Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 1: General rules*

IEC 61009-1, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 62873-2, *Residual current operated circuit-breakers for household and similar use – Part 2: Residual current devices (RCDs) – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62873-2 and the following apply.

3.1
treated conductor
contact area of a conductor that has had its oxide layer on the outside strands scraped away and/or has had a compound added to improve connectability and/or prevent corrosion

3.2
untreated conductor
unprepared conductor
conductor which has been cut and the insulation of which has been removed for insertion into a terminal

Note 1 to entry: A conductor, the shape of which is arranged for introduction into a terminal or the strands of which are twisted to consolidate the end, is considered to be an unprepared conductor.

[SOURCE: IEC 60050-442:1998, 442-01-26]

3.3
equalizer
arrangement used in the test loop to ensure an equipotentiality point and uniform current density in a stranded conductor, without adversely affecting the temperature of the conductor(s)

3.4
reference conductor
continuous length of the same type and size conductor as that used in the terminal unit under test and connected in the same series circuit, which enables the reference temperature and, if required, reference resistance to be determined

3.5
stability factor
Sf
measure of temperature stability of a terminal unit during the current cycling test

4 Classification

Clause 4 of the RCD product standard applies.

5 Characteristics of RCDs

Clause 5 of the RCD product standard applies.

6 Marking and other product information

In addition to Clause 6 of the RCD product standard, the following requirements apply.

The terminal marking defined in Table 1 shall be marked on the RCD, near the terminals.

The other information concerning the number of conductors, the screw torque values (if different from Table 11 of the RCD product standard) and the cross-sections shall be indicated on the RCD.

NOTE Tables 6, 10, 11 (in IEC 61008-1:2010) and Tables 8, 13, 14 (in IEC 61009-1:2010) have been replaced by the harmonized new numbers: 9, 10 and 11.

Table 1 – Marking for terminals

Conductor types accepted	Marking
Copper only	None
Aluminium only	Al
Aluminium and copper	Al/Cu

The manufacturer shall state in his catalogue that, for the clamping of an aluminium conductor, the tightening torque shall be applied with appropriate means.

7 Standard conditions for operation in service and for installation

Clause 7 of the RCD product standard applies.

8 Requirements for construction and operation

Clause 8 of the RCD product standard applies, with the following exceptions:

The following text is added at the end of 8.1.5.2 of the RCD product standard:

For the connection of aluminium conductors, RCDs shall be provided with screw-type terminals allowing the connection of conductors having nominal cross-sections as shown in Table 2.

Terminals for the connection of aluminium conductors and terminals of aluminium for the connection of copper or aluminium conductors shall have mechanical strength adequate to withstand the tests of 9.4 of the RCD product standard, with the test conductors tightened with the torque indicated in Table 11 of the RCD product standard, or with the torque specified by the manufacturer, which shall never be lower than that specified in Table 11 of the RCD product standard.

Table 2 – Connectable cross-sections of aluminium conductors for screw-type terminals

Rated current [a] A	Range of nominal cross-sections [b] to be clamped mm^2
Up to and including 25	10
Above 25 up to and including 32	10 to 16
Above 32 up to and including 50	10 to 25
Above 50 up to and including 80	10 to 35
Above 80 up to and including 100	16 to 50
Above 100 up to and including 125	25 to 70

[a] It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors; the use of flexible conductors is permitted. Nevertheless, it is permitted that terminals for conductors having cross-sections up to 10 mm^2 be designed to clamp solid conductors only.

[b] Maximum wire sizes of RCD product standard, increased according to Table D.2 of IEC 61545:1996.

Compliance is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-section areas as specified.

8.1.5.4 of the RCD product standard is replaced by the following text:

8.1.5.4 Terminals shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection and the tests of Clause 9.

9 Tests

9.1 General

Clause 9 of the RCD product standard applies, with the following modifications/additions:

For the tests which are influenced by the material of the terminal and the type of conductor that can be connected, the test conditions of Table 3 are applied.

Additionally, the test of 9.3 is carried out on terminals separated from the RCD.

Table 3 – List of tests according to the material of conductors and terminals

Material of terminals	**Material according to 8.1.4.4** [a]	**Al** [a]	
Material of conductor (Table 1)	Al Use Tables 2 and 5 of this standard	Cu Use Tables 24 and 25 of the RCD product standard	Al Use Tables 2 and 5 of this standard
9.4 Reliability of screws	Use Table 2 of this standard and Table 26 of the RCD product standard	Use Tables 24, 25 and 26 of the RCD product standard	Use Table 2 of this standard and Table 26 of the RCD product standard
9.5.1 Pull-out test [b]	Use Table 2 of this standard and Table 26 of the RCD product standard	Use Tables 24, 25 and 26 of the RCD product standard	Use Table 2 of this standard and Table 26 of the RCD product standard
9.5.2 Damage of the conductor	Use Table 2 of this standard and Table 26 of the RCD product standard	Use Tables 24, 25 and 26 of the RCD product standard	Use Table 2 of this standard and Table 26 of the RCD product standard
9.5.3 Insertion of the conductor	Use Table 5 of this standard	Use Table 25 of the RCD product standard	Use Table 5 of this standard
9.8 Temperature rise	Use Table 5 of this standard	Use Table 25 of the RCD product standard	Use Table 5 of this standard
9.22 Verification of reliability	Use Table 5 of this standard	Use Table 25 of the RCD product standard	Use Table 5 of this standard
9.2 Cycling test	Use Table 26 of the RCD product standard	Use Table 26 of the RCD product standard	Use Table 26 of the RCD product standard

[a] Use test sequences A and B and number of samples defined in Annex A. For RCDs which are able to be connected to Al or Cu conductors, the test sequences and number of samples have to be doubled (one for the Cu conductor and one for the Al conductor).

[b] For the pull-out test in 9.5.1, the value for 70 mm^2 wire is under consideration.

The dimensions of connectable conductors are given in Table 4.

Table 4 – Connectable conductors and their theoretical diameters

Metric					AWG				
Rigid			Flexible (copper only)		Rigid			Flexible (copper only)	
S	**Solid**	**Stranded**	***S***			**Solid** [a]	**Class B stranded** [a]		**Classes**[b] **I, K, M stranded**
mm^2	Ø mm	Ø mm	mm^2	Ø mm	Gauge	Ø mm	Ø mm	Gauge	mm
1,0	1,2	1,4	1,0	1,5	18	1,07	1,23	18	1,28
1,5	1,5	1,7	1,5	1,8	16	1,35	1,55	16	1,50
2,5	1,9	2,2	2,5	2,3[c]	14	1,71	1,95	14	2,08
4,0	2,4	2,7	4,0	2,9[c]	12	2,15	2,45	12	2,70
6,0	2,9	3,3	4,0	2,9[c]	10	2,72	3,09		
10,0	3,7	4,2	6,0	3,9	8	3,43	3,89	10	3,36
16,0	4,6	5,3	10,0	5,1	6	4,32	4,91	8	4,32
25,0		6,6	16,0	6,3	4	5,45	6,18	6	5,73
35,0		7,9	25,0	7,8	2	6,87	7,78	4	7,25
					1	7,72	8,85		
50,0		9,1	35	9,2	0	8,51	9,64		12,08
70,0		12,0	50	12	0	9,266	10,64		

NOTE Diameters of the largest rigid and flexible conductors are based on IEC 60228:2004, Table 1 and, for AWG conductors, on ASTM B 172-01a.

[a] Nominal diameter + 5 %.

[b] Largest diameter + 5 % for any of the three classes I, K, M.

[c] Dimensions for class 5 flexible conductors only, according to IEC 60228.

9.2 Test conditions

Subclause 9.2 of the RCD product standard applies, except that the Al conductors to be connected are taken from Table 5.

Table 5 – Cross-sections (*S*) of aluminium test conductors corresponding to the rated currents

S mm^2	I_n A
10	$I_n \leq 32$
16	$32 < I_n \leq 50$
25	$50 < I_n \leq 63$
35	$63 < I_n \leq 80$
50	$80 < I_n \leq 100$
70	$100 < I_n \leq 125$

9.3 Current cycling test

9.3.1 General

This test verifies the stability of the screw-type terminal by comparing the temperature performance with that of the reference conductor under accelerated cycling conditions.

This test is carried out on separate terminals.

9.3.2 Preparation

The test is performed on four specimens, each one made by a couple of terminals, assembled in a manner which represents the use of the terminals in the RCD (see examples shown in Figures 2 to 6). The screw-type terminals which have been removed from the product shall be attached to the conducting parts of the same cross-section, shape, metal and finish as that on which they are mounted on the product. The screw-type terminals shall be fixed to the conducting parts in the same manner (position, torque, etc.) as on the product. If one specimen fails during the test, four other specimens shall be tested and no other failures are admitted.

9.3.3 Test arrangement

The general arrangement of the samples shall be as shown in Figure 1.

90 % of the value of torque stated by the manufacturer or, if not stated, selected in Table 11 of the RCD product standard shall be used for the test specimens.

The test is carried out with conductors according to Table 5. The length of the test conductor from the point of entry to the screw-type terminal specimens to the equalizer (see 3.3) shall be as in Table 6.

Table 6 – Test conductor length

Conductor cross-section mm^2	Conductor wire size AWG	Minimum conductor length mm
$S \leq 10,0$	≤ 8	200
$16,0 \leq S \leq 25,0$	6 to 3	300
$35,0 \leq S \leq 70,0$	2 to 00	460

Test conductors are connected in series with a reference conductor of the same cross-section.

The length of the reference conductor shall be approximately at least twice the length of the test conductor.

Each free end of the test and reference conductor(s) not connected to a screw-type terminal specimen shall be welded or brazed to a short length of an equalizer of the same material as the conductor and of cross-section not greater than that given in Table 7. All strands of the conductor shall be welded or brazed to make an electrical connection with the equalizer.

Tool-applied compression type terminations without welding may be used for the equalizer if acceptable to the manufacturer and if the same performance is provided.

Table 7 – Equalizer and busbar dimensions

Range of test current	Maximum cross-section mm^2	
A	Al	Cu
0 to 50	45	45
51 to 125	105	85
126 to 225	185	155

The separation between the test and reference conductors shall be at least 150 mm.

The test specimen shall be suspended either horizontally or vertically in free air by supporting the equalizer or busbar by non-conductive supports so as not to subject the screw-type terminal to a tensile load. Thermal barriers shall be installed midway between the conductors and shall extend 25 mm ± 5 mm widthways and 150 mm ± 10 mm lengthways beyond the screw-type terminals (see Figure 1). Thermal barriers are not required provided the specimens are separated by at least 450 mm. The specimens shall be located at least 600 mm from the floor, wall or ceiling.

The test specimens shall be located in a substantially vibration-free and draught-free environment and at an ambient temperature between 20 °C and 25 °C. Once the test is started, the maximum permissible variation is ±1 K provided the range limitation is not exceeded.

9.3.4 Temperature measurement

Temperature measurements are made by means of thermocouples, using a wire having a cross-section of not more than 0,07 mm^2 (approximately 30 AWG).

For screw-type terminals, the thermocouple shall be located on the conductor entry side of the screw-type terminal, close to the contact interface.

For the reference conductor, the thermocouples shall be located midway between the ends of the conductor, and under its insulation.

Positioning of the thermocouples shall not damage the screw-type terminal or the reference conductor.

NOTE 1 Drilling of a small hole and subsequent fastening of the thermocouple is an acceptable method, provided that the performance is not affected and that it is agreed by the manufacturer.

The ambient temperature shall be measured with two thermocouples in such a manner as to achieve an average and stable reading in the vicinity of the test loop without undue external influence. The thermocouples shall be located in a horizontal plane intersecting the specimens, at a minimum distance of 600 mm from them.

NOTE 2 A satisfactory method for achieving a stable measurement is, for example, to attach the thermocouple to unplated copper plates approximately 50 mm × 50 mm, having a thickness between 6 mm and 10 mm.

9.3.5 Test method and acceptance criteria

NOTE 1 Evaluation of performance is based on both the limit of screw-type terminal temperature rise and the temperature variation during the test.

The test loop shall be subjected to 500 cycles of 1 h current-on and 1 h current-off, starting at an alternating current equal to 1,12 times the test current value determined in Table 8. Near the end of each current-on period of the first 24 cycles, the current shall subsequently be adjusted to raise the temperature of the reference conductor to 75 °C.

At the 25th cycle, the test current shall be adjusted for the last time and the stable temperature shall be recorded as the first measurement. There shall be no further adjustment of the test current for the remainder of the test.

Temperatures shall be recorded for at least one cycle of each working day, and after approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles.

The temperature shall be measured during the last 5 min of the current-on time. If the size of the set of test specimens or the speed of the data acquisition system is such that not all measurements can be completed within 5 min, the current-on time shall be extended as necessary to complete such measurements.

After the first 25 cycles, the current-off time may be reduced to a time 5 min longer than the time necessary for all terminal assemblies to cool down to a temperature between ambient temperature T_a and T_a + 5 K during the current-off period. Forced-air cooling may be employed to reduce the off time, if acceptable to the manufacturer. In that case, it shall be applied to the entire test loop and the resulting temperature of the forced air shall not be lower than the ambient air temperature.

The stability factor Sf for each of the 11 temperature measurements is to be determined by subtracting the average temperature deviation *D* from the 11 values of the temperature deviation *d*.

The temperature deviation *d* for the 11 individual temperature measurements is obtained by subtracting the associated reference conductor temperature from the screw-type terminal temperature.

NOTE 2 The value of *d* is positive if the screw-type temperature is higher than that of the reference conductor and negative if it is lower.

For each screw-type terminal:

– the temperature rise shall not exceed 110 K;

– the stability factor Sf shall not exceed ±10 °C.

An example of calculation for one screw-type terminal is given in Table 9.

Table 8 – Test current as a function of rated current

Metric sizes			AWG		
Rated current	**Al conductor size**	**Test current**	**Rated current**	**Al conductor size**	**Test current**
A	mm²	A	A	No.	A
–	–	–	$0 < I_n \leq 15$	–	30
–	–	–	$15 < I_n \leq 25$	–	40
–	–	–	$25 < I_n \leq 40$	8	53
$0 < I_n \leq 32$	10	60	$40 < I_n \leq 50$	6	69
$32 < I_n \leq 50$	16	79	$50 < I_n \leq 65$	4	99
$50 < I_n \leq 65$	25	99	$65 < I_n \leq 75$	3	110
$65 < I_n \leq 80$	35	137	$75 < I_n \leq 90$	2	123
$80 < I_n \leq 100$	50	171	$90 < I_n \leq 100$	1	152
$100 < I_n \leq 125$	70	190	$100 < I_n \leq 120$	0	190

Table 9 – Example of calculation for determining the average temperature deviation *D*

Temperature measurement	Cycle number	Temperatures		Temperature deviation $d = a - b$	Stability factor $Sf = d - D$
		Screw-type terminal *a*	Reference conductor *b*		
		°C	°C	K	K
1	25	79	78	1	0,18
2	50	80	77	3	2,18
3	75	78	78	0	−0,82
4	100	76	77	−1	−1,82
5	125	77	77	0	−0,82
6	175	78	77	1	0,18
7	225	79	76	3	2,18
8	275	78	76	2	1,18
9	350	77	78	−1	−1,82
10	425	77	79	−2	−2,82
11	500	81	78	3	2,18

Average temperature deviation $D = \frac{\sum d}{n} = \frac{9}{11} = 0{,}82$, where *n* is the number of measurements.

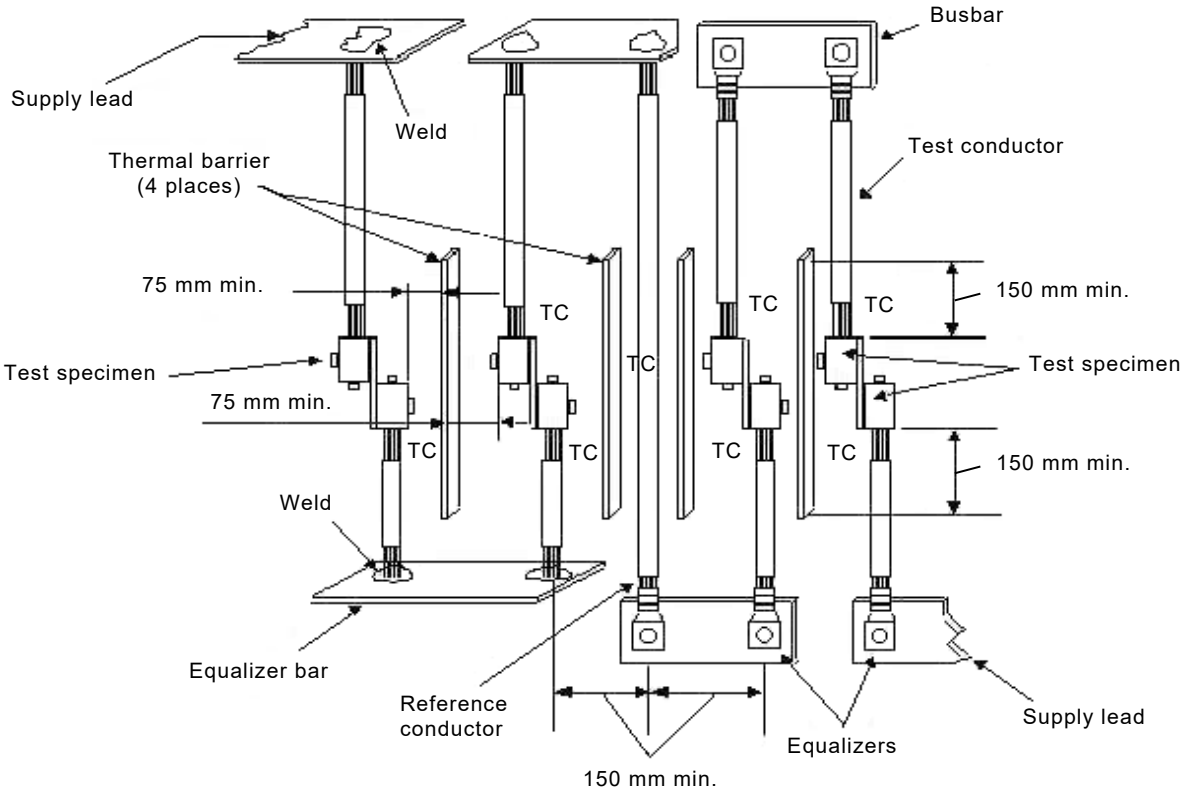
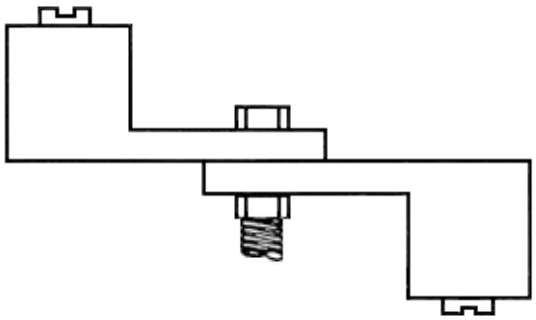


Figure 1 – General arrangement for the test



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NOTE The conducting part can be bolted, soldered or welded.

Figure 2 – Test specimen example 1

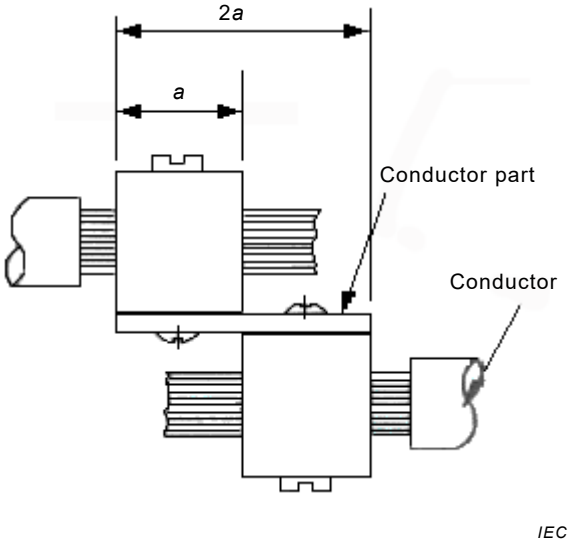

Figure 3 – Test specimen example 2

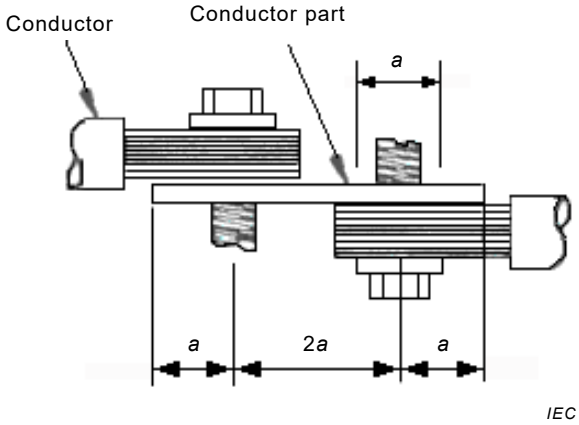

Figure 4 – Test specimen example 3

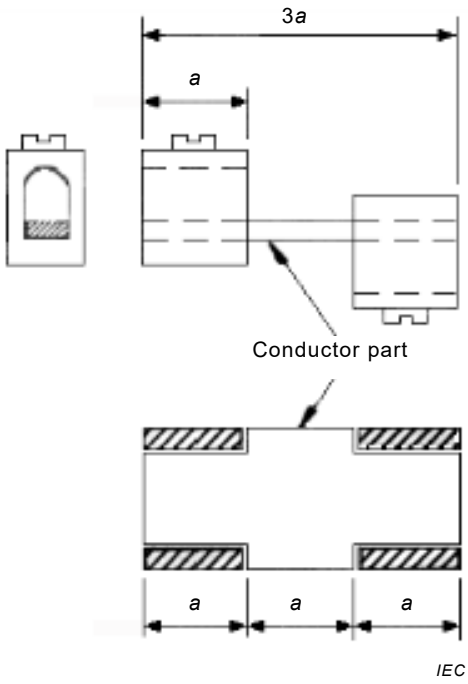

Figure 5 – Test specimen example 4

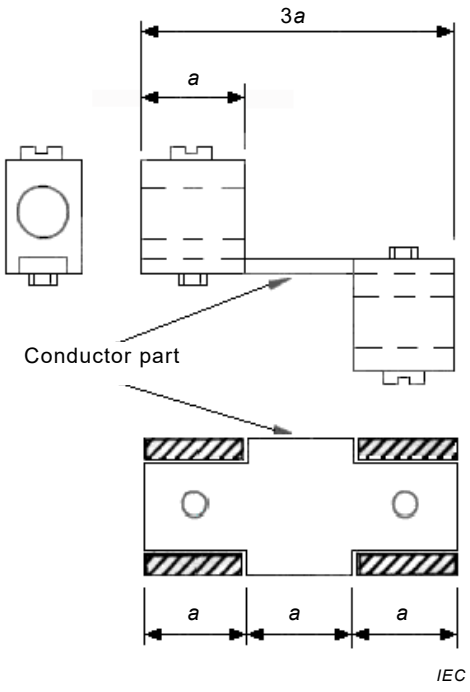

Figure 6 – Test specimen example 5

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ASTM B172-10, *Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors*

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