

BS EN 3475-604:2010



BSI Standards Publication

Aerospace series — Cables, electrical, aircraft use — Test methods

Part 604: Resistance to dry arc propagation

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The UK participation in its preparation was entrusted to Technical Committee ACE/6, Aerospace avionic electrical and fibre optic technology.

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

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Foreword

This document (EN 3475-604:2010) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2011, and conflicting national standards shall be withdrawn at the latest by January 2011.

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1 Scope

This standard specifies a method for appraising the behaviour of cable insulation when an electric arc is initiated and maintained by two powered cables rubbing against a blade.

This standard shall be used together with EN 3475-100.

The primary aim of this test is:

to produce, in a controlled fashion, continuous failure effects which are representative of those which may occur in service when a typical cable bundle is damaged by abrasion such that electrical arcing occurs, both between cables and between cables and conductive structure; and

to examine the aptitude of the insulation to track, to propagate electric arc to the electrical origin.

Originally defined for 115 Vac network, this test also proposes conditions for 230 Vac network. Unless otherwise specified in product standard, only 115 Vac conditions shall be satisfied.

Six levels of prospective fault current have been specified for concerned cable sizes (see Clause 7). It is generally agreed that larger sizes need not be assessed since the short-circuit phenomenon becomes dominant at low line impedances.

Unless otherwise specified in the technical/product standard sizes 002, 006 and 020 cable shall be assessed.

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.

EN 2350, *Aerospace series — Circuit breakers — Technical specification*

EN 2702:2005, *Aerospace series — Aluminium alloy AL-P6061 — T6 or T62 — Drawn or extruded bar and section — a or D ≤ 200 mm*

EN 3197, *Aerospace series — Installation of aircraft electrical and optical interconnection systems*¹⁾

EN 3475-100, *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General*

EN 3475-302, *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 302: Voltage proof test*

A-A-52083, *Tape, lacing and tying, glass*²⁾

1) Published as ASD STAN Prestandard at the date of publication of this standard.

2) Published by: Department of Defense Industrial Supply Center, ATTN: DISC-BBEE, 700 Robbins Avenue, Philadelphia, PA 19111-5096 – USA.

3 Specimen requirements

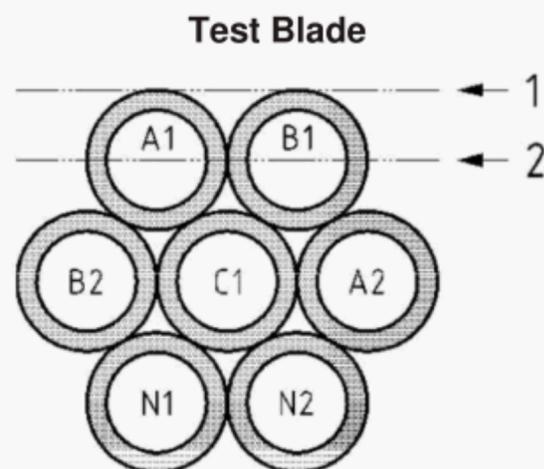
Cables to be tested shall be of traceable origin and shall have passed the high voltage dielectric test defined in the product standard.

4 Preparation of specimen

4.1 Cut seven separate lengths of approximately 0,5 m consecutively from one length of cable, and strip each of the ends of insulation to permit electrical connection. Clean each length of cable with a clean cloth moistened with propan-2-ol (isopropyl alcohol) fluid.

4.2 Lay up the seven cables as follows:

- a) Form the cables in a six around one configuration as shown in Figure 1.
- b) Ensure that all cables are straight and geometrically parallel, and restrained by ties such that they are in continuous contact for at least a 75 mm continuous length around the mid point of the loom length. This is called the test zone.
- c) Position the ties at 15 mm to 20 mm spacing within the test zone. The tie material shall be PTFE glass lacing tape conforming to A-A-52083, type IV, finish D, size 3.
- d) Number the cables as shown in Figure 1 such that the cables in contact with the blade are numbers A1 and B1.



Key

- 1 Original position
- 2 Final position
- A1-A2: Phase A
- B1-B2: Phase B
- C1-C2: Phase C
- N1-N2: Inactive cables connected to earth

Figure 1 — Specimen configuration

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5 Apparatus

5.1 Electrical equipment

Connect the seven cables of the test sample within a circuit as shown in Figure 2. This circuit shall have the following requirements:

- a) The provision of adjustable levels of prospective fault currents for the five A, B and C cables and an electrical return path for the two N cables.
- b) A three phase 115/200 V 400 Hz (115 Vac network) or 230/400 V 400 Hz (230 Vac network) star (Y) connected supply shall be derived from a dedicated rotary machine capable of sustaining the maximum prospective fault current given in Table 1 for at least sufficient time for circuit protection to operate. In any case the generator shall have a sufficient rating to provide these prospective fault currents.
- c) 115 Vac or 230 Vac circuit breakers shall be single pole units rated at the values specified in Table 2. They shall have trip characteristics in accordance with EN 2350 or as required in the product specification.

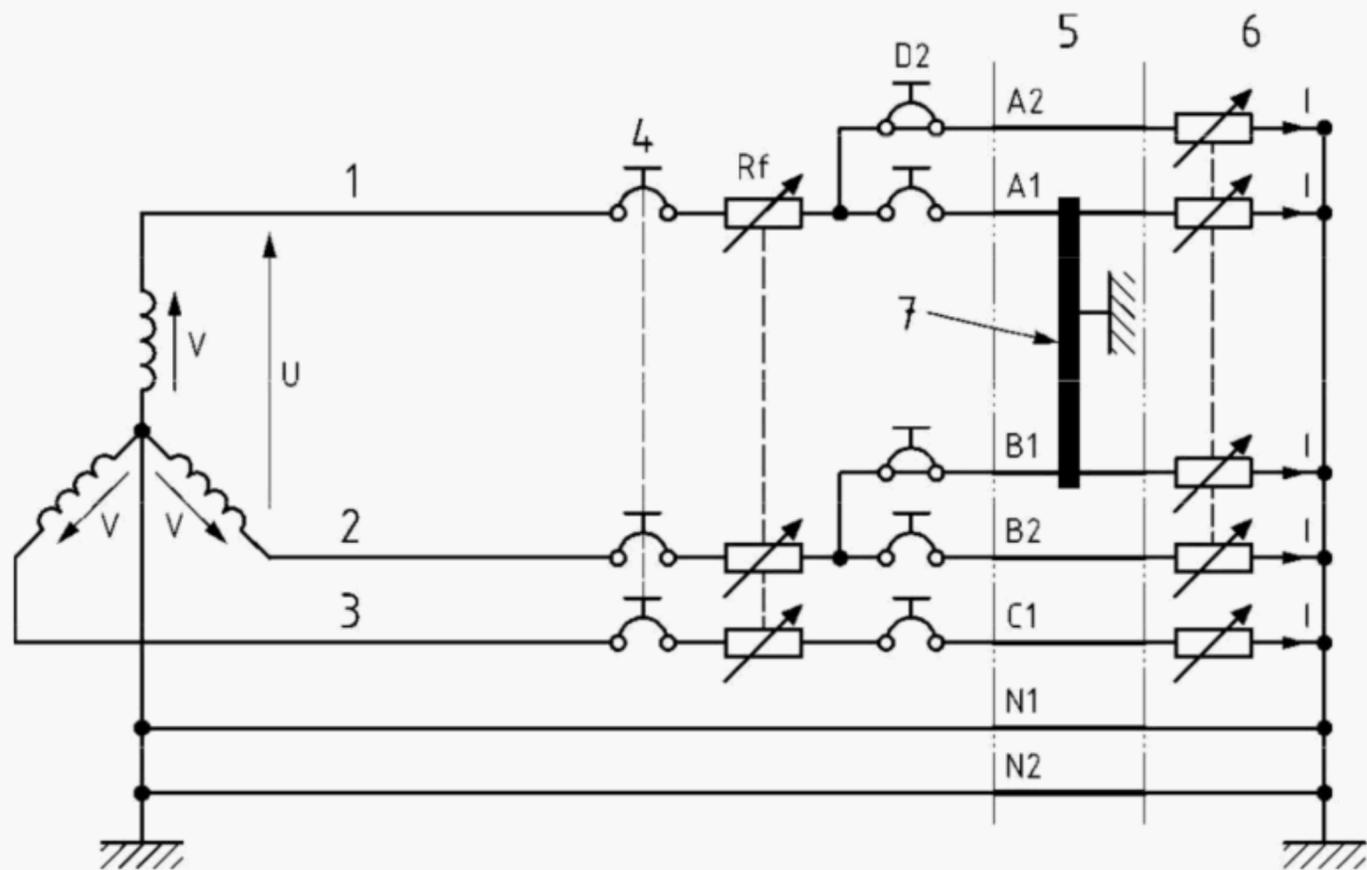
NOTE 1 Reference of circuit breakers used should be recorded.

NOTE 2 In particular case, others ratings of thermal breaker protection could be employed in accordance with aircraft manufacturer rules.

- d) The electrical power source shall be appropriately protected and it shall be established that no combination of test circuit events would activate this protection.
- e) The ballast resistors shall be non-inductive and of appropriate power rating. Care shall be taken to position all laboratory wiring such that inductive effects are reduced to a practical minimum. Supply cables shall be as short as possible.
- f) Cables A, B and C shall be connected to indication and open circuit detectors at entry into the grounded star point. These components shall limit the standing current to no more than 10 % of the circuit breaker rating.
- g) The automatic shut down facility shall provide, upon the detection of any open circuit during test and after a 10 s delay, removal of the blade from the specimen and for electrical power to be removed. Open circuit in this case means either a physical break in the specimen or a thermal breaker trip.

NOTE In the case of the automatic shut down facility is not used, the physical break in the specimen are detected by lamps in series with the rheostat Rg.

- h) A heavy duty electrical bonding strap shall be connected between the blade of the test rig and the electrical star point of the generator.
- i) Appropriate instrumentation, recording and switching control shall be installed in accordance with good laboratory practice.
- j) A rheostat Rg adjusting current (I) in the circuit to a value equal to 10 % of the circuit breaker current.



Key

- Rf Rheostat
- 1 Phase A
- 2 Phase B
- 3 Phase C
- 4 Supply protection
- 5 Test bundle
- 6 Indicators (lamp) + Rp
- 7 Test blade

Figure 2 — Test schematic circuit

5.2 Test equipment

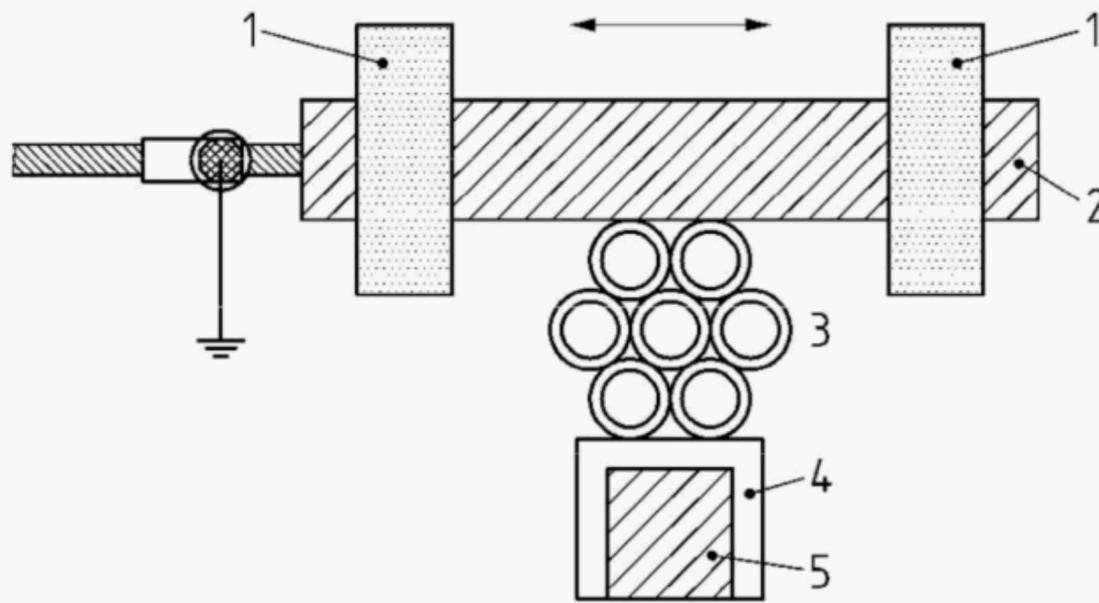
Construct an apparatus as shown diagrammatically in Figures 3, 4 and 5 which includes the following minimum provisions:

- a) A lightweight, freely pivoting test fixture to hold the blade at a 90° angle to the specimen and to exert a controlled force on the specimen.

NOTE Generally a mounting on 50 mm centres should hold the individual cables of the specimen in close proximity.

- b) Electrical terminations to provide a ready means of connecting test specimens into the circuit as shown in Figure 2.
- c) An aluminium blade complying with material specification T6061-T6 (EN 2702:2005) and Figure 5.
- d) A mechanism to provide a minimum oscillating stroke of 15 mm excursion at a frequency of (8 ± 2) Hz.
- e) A blade carrier to give a downward force at the blade of $(2,5 \pm 0,1)$ N.
- f) A mechanical stop to limit the fall of the oscillating blade to within an accuracy of 0,2 mm measured at the point of contact.

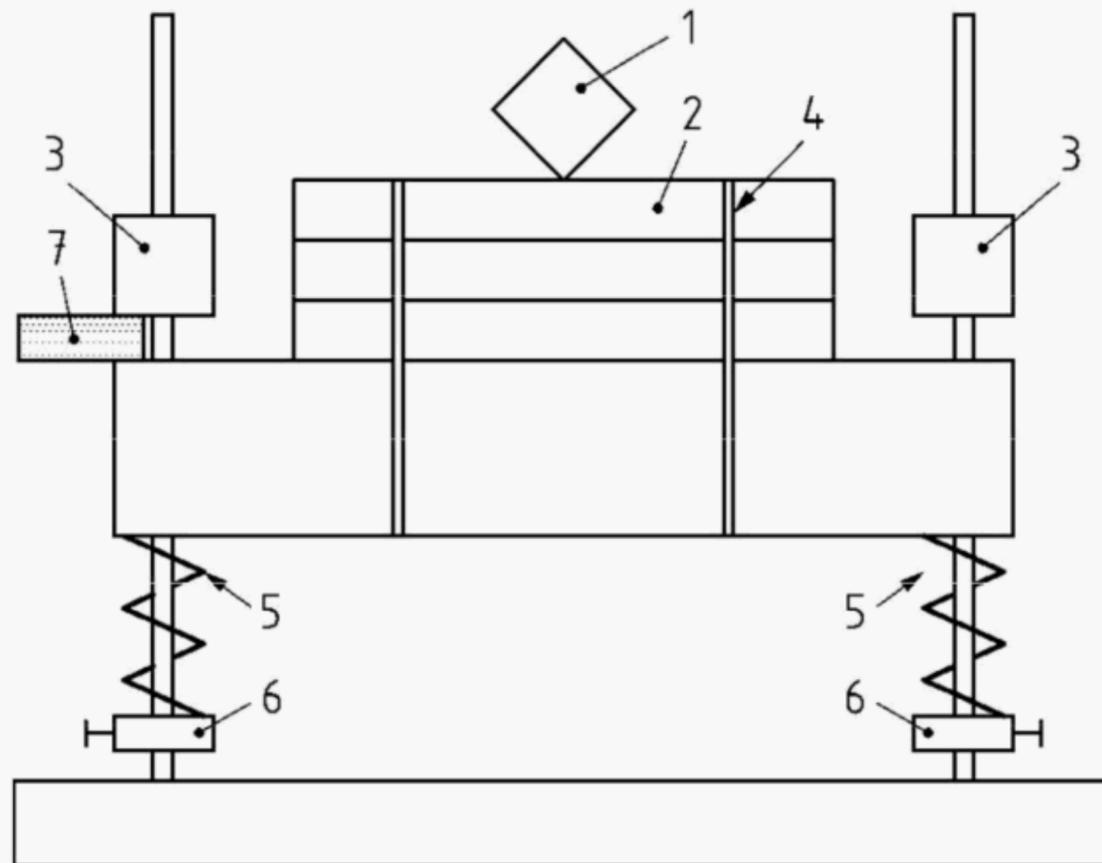
- g) Means of separating the blade from the specimen, both manually and automatically if used.
- h) An electrical connection of the aluminium blade to the neutral of the test power supply (see 5.1, h)).
- i) A transparent enclosure to protect personnel from ejected molten metal and short wavelength ultra violet light.



Key

- 1 Blade carrier guide
- 2 Aluminium blade
- 3 Bundle
- 4 Heat insulation (e.g.: PTFE)
- 5 Aluminium support

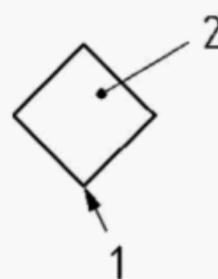
Figure 3



Key

- 1 Blade
- 2 Bundle
- 3 Stop
- 4 Cable tie
- 5 Spring
- 6 Contact pressure adjustment
- 7 Depth adjustment shim

Figure 4



Key

- 1 Sharpen edge with 60 grit aluminum disc sander directed "towards the blade" (i.e. to avoid feathered edge)
- 2 Aluminium square (10 mm)

Figure 5

5.3 Test protocol

5.3.1 The procedure embraces copper cable sizes 001 to 050 (26 to 10) or aluminium cable sizes 002 to 090 (24 to 8), and for each cable size six values of prospective fault current have been defined. Performance of a cable size at a given fault intensity shall be determined by testing three samples. Thus 18 samples are required for every cable size.

5.3.2 For the purposes of cable qualification at least sizes 002, 006 and 020 shall be tested. Additional testing of other sizes may be deemed necessary in particular cases and values of prospective fault currents, the ratings of thermal breaker protection which are typical of aircraft use and the blade form to be employed have been included in this specification.

5.3.3 It is emphasized that electrical arcing tests are essentially destructive and can be hazardous to personnel. Therefore tests shall be undertaken with all observers shielded from direct physical and visual exposure as noted in 5.2, i). The use of video recording for all tests is required.

5.4 Test rig set-up

5.4.1 Install the rating of circuit breaker appropriate to the cable type and size to be tested (Table 2). Fit a blade to the reciprocating head of the test rig of the appropriate type shown in Figures 3 and 4.

5.4.2 Heavy duty electrical shorting connections shall be fitted in substitution of a test sample to enable prospective fault currents to be set by adjustment of resistances R_f . Because these currents would trip the thermal breakers very rapidly these shall be shunted to permit the pulsing of current until the desired value is obtained. Re-instate the thermal protection.

5.4.3 With electrical power removed adjust the test apparatus to give the correct conditions of blade stroke, frequency and downwards force. Ensure that the test fixture is correctly positioned and that the method of holding the specimen provides satisfactory restraint.

5.4.4 Modify a verification sample by removing a section of cables A1 and B1 in the test zone. Adjust the blade depth stop such that the final blade position is at least half the conductor diameter of A1 or B1, from wires A2, B2 and C1, as shown by Figure 1.

6 Method

6.1 Test procedure

6.1.1 Install a test specimen with electrical connections as shown in Figure 1 and with R_f set, as in 5.4.2 above, to give the required current from Table 1.

6.1.2 Apply electrical power to the specimen and gently make contact with the blade. Arm the automatic blade lifting circuit, if used, and start the abrading action.

NOTE 1 Only blades in good condition should be used on new samples. If the abrading edge of a blade becomes significantly degraded after a circuit breaker trip at any stage it should be replaced.

NOTE 2 Before each test series check that thermal breakers are operating within their specified trip limits when subjected to 100 % overload.

NOTE 3 Shall it be established that the mechanical attack of the blade does not penetrate the insulation within 3 min, then it is permissible for a fine cut to be made on the test specimens at the point on the upper surface of cables A1 and B1 where the blade is to make contact. No material should be removed and the cut should not penetrate to the conductor.

6.1.3 Actuation of the abrader shall create failure effects which shall be processed as follows:

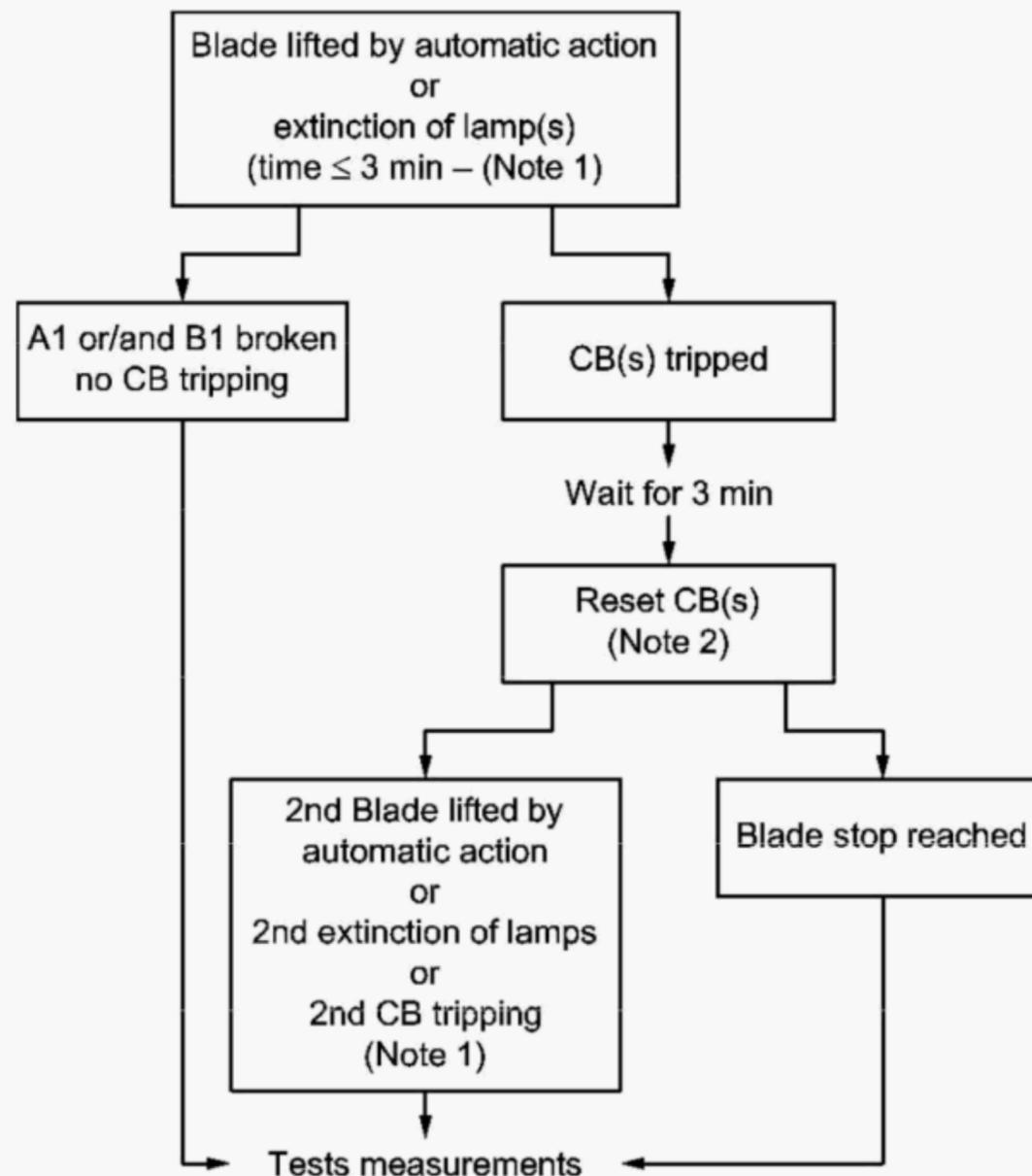


Figure 6

NOTE 1 If the automatic shut down is not used, switch off the power and the removal of the blade manually.

NOTE 2 If the automatic shut down is not used, reset the power and actuate the blade manually.

6.1.4 Repeat the test to obtain three samples and then reset the circuit for the next highest current overload until all 18 samples have been tested.

6.2 Examination

6.2.1 EN 3197 can be used as a guideline to differentiate short-circuit and arc-tracking effects.

Noticeable damages may come from ever:

- aptitude of the insulation to become an electrically conducting material (arc-tracking phenomenon);
- propagation of thermal effects due to established arcs;
- duration of the test causing electro-erosion;
- as result of thermal effects due to possible short-circuit.

6.2.2 Carefully remove the test specimen from the apparatus and photograph the cable bundle.

6.2.3 Examine visually and record the damage to the insulation including the length of char. Also record if damages are centred on the contact point or if there is evidence of tracking effect to the electrical source.

6.2.4 For 115 Vac network and only if there is evidence of tracking effect, with minimal mechanical disturbance to the test specimen, carry out a voltage proof test EN 3475-302 – Immersion test at 1 000 V 1mn, in turn on each of the cables except cables A1 and B1.

6.2.5 For 230 Vac network, considering that short-circuit effect becomes preponderant and produces strong collateral damages, a voltage proof test shall be un-necessary.

6.3 Test report

The test report shall include details of the following:

- a) clearly mentioned which type of tension was tested (115 Vac or 230 Vac);
- b) identity of the cable type and size and details of the origin and release certification permitting traceability to a production batch;
- c) identity of circuit breakers used;
- d) characteristics of the power source;
- e) operation of individual circuit breakers;
- f) record of the damage as required in 6.2.3 and the result of voltage proof test as required in 6.2.4.

7 Requirements

The detail product specification shall define: tension to test if different from 115 Vac, the pass/fail criteria for each cable size, in any series of tests. In any case the cable shall not present evidence of tracking effect longer than the value mentioned in the related product specification.

Table 1 — Prospective fault currents

Type of cables	Size code	AWG ^a	Prospective fault currents					
			A					
Copper conductors	001/002	26/24	8	15	25	40	60	80
	004/006	22/20	20	30	45	60	80	160
	010 to 051	18 to 10	40	60	80	100	125	250
Copper Clad Aluminium conductors	002/004	24/22	8	15	25	40	60	80
	006/010	20/18	20	30	45	60	80	160
	012/090	16 to 8	40	60	80	100	125	250

NOTE As the maximum current acceptable by a cable size is directly linked to its cross-section, the same prospective fault currents should be retained per size for 115 Vac and 230 Vac networks.

^a AWG = Closest American Wire Gage.

Table 2 — Circuit breaker ratings

Type of cables	Size code	001	002	004	006	010	012	020	030	050	090
	AWG ^a	26	24	22	20	18	16	14	12	10	8
Copper conductors	CB ratings [A]	3	5	7,5	10	10	15	20	25	50	—
Copper Clad Aluminum conductors		—	3	5	7,5	10	10	15	20	35	50

^a — AWC = Closest American Wire Gauge.

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