

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Live working – Insulating aerial devices for mounting on a chassis

Travaux sous tension – Dispositifs élévateurs isolants pour montage sur un châssis



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Live working – Insulating aerial devices for mounting on a chassis

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CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references	9
3 Terms and definitions	10
4 Specific terms and nomenclature	19
5 Requirements	22
5.1 Controls	22
5.1.1 Activation and operation	22
5.1.2 Duplicate controls	23
5.1.3 Emergency stop.....	23
5.1.4 Control of outriggers	24
5.1.5 Monitoring of radio and optical fibre controls.....	24
5.1.6 High electrical resistance upper control system(s)	24
5.2 Failure of the source of power.....	24
5.3 Restoration of power after failure	24
5.4 Boom travel protection	24
5.5 Chassis inclination	25
5.6 Locking pins.....	25
5.7 Electrical requirements	25
5.7.1 Insulating systems	25
5.7.2 Insulating booms (including lower boom insulating insert / chassis insulating system).....	25
5.7.3 Non-conductive/insulating hydraulic hoses and lines	26
5.7.4 Insulating fixed handling tools.....	26
5.7.5 Insulating optical fibre cables.....	26
5.7.6 Equipotential bonding	26
5.7.7 Lower test electrode system	27
5.7.8 Corona effect.....	31
5.7.9 Gradient control devices	31
5.7.10 Chassis insulating system bypass.....	31
5.7.11 Chassis earthing system	32
5.8 Particular mechanical requirements	32
5.8.1 Structural design	32
5.8.2 Stability	33
5.8.3 Wind speed	33
5.9 Speeds of the extending structure.....	33
5.10 Load sensing	33
5.11 Requirements for the hydraulic system	33
5.11.1 Hydraulic depressurization (vacuum protection).....	33
5.11.2 Hydraulic pressure rise	33
5.11.3 System protection.....	33
5.11.4 Overriding safety devices	34
5.11.5 Pressure limiting device.....	34
5.11.6 Bursting strength – hoses and fittings	34
5.11.7 Fluid level indicators	34
5.11.8 Fluid cleanliness.....	34

5.12	Requirements for the platforms	34
5.12.1	Platform security.....	34
5.12.2	Platform levelling	34
5.12.3	Guardrail system	35
5.12.4	Baskets	35
5.12.5	Personnel safety attachments (and attachment for fall protection)	35
5.13	Marking.....	35
5.14	Instructions for use	36
5.15	Dimensions and mass	36
6	Tests	36
6.1	General.....	36
6.2	Visual and dimensional check	37
6.3	Design check and functional testing	37
6.4	Durability of markings	37
6.5	Dye penetration test of insulating foam-filled booms	37
6.6	Electrical tests	38
6.6.1	General	38
6.6.2	Electrical tests for insulating booms, insulating fixed handling tools and optical fibre cables.....	38
6.6.3	Test of insulating baskets or liners.....	50
6.6.4	Dielectric test of the insulating fixed handling tools.....	51
6.7	Dielectric tests of the insulating systems of the complete aerial devices	52
6.7.1	General	52
6.7.2	Aerial devices with lower test electrode system	52
6.7.3	Aerial devices without lower test electrode system.....	55
6.8	Lower test electrode system.....	61
6.9	Equipotential bonding	61
6.10	Mechanical tests	61
6.10.1	Mechanical tests on insulating boom with its fittings	61
6.10.2	Platform creep	62
6.10.3	Hydraulic depressurization (vacuum protection).....	62
6.11	Design and functional tests	63
7	Conformance testing of aerial devices after completion of the production phase	63
8	Modifications	63
	Annex A (informative) Guidelines for selecting the characteristics of insulating aerial devices as a function of the live working methods	64
A.1	General.....	64
A.2	Bare hand live working.....	64
A.3	Live line tool, distance or hot stick working	64
A.4	Insulating (rubber) glove working	65
A.5	Use under DC	65
A.6	Advice for buyers of insulating aerial devices meeting the requirements of this document not intending to make use of them for live working	65
	Annex B (normative) Suitable for live working; double triangle IEC-60417-5216:2002-10	66
	Annex C (normative) General type test procedure	67
	Annex D (normative) Classification of defects and tests to be allocated	69
	Annex E (informative) Care and maintenance	71
E.1	General.....	71

E.2	Care of insulating components	71
E.2.1	Care whilst in transit	71
E.2.2	Care during work activities	71
E.2.3	Storage	72
E.3	Maintenance of insulating components	72
E.3.1	General	72
E.3.2	Cleaning	72
E.3.3	Siliconing or waxing	73
E.4	Inspection of insulating components	73
E.4.1	General	73
E.4.2	Pre-start inspection	73
E.4.3	Frequent and annual inspections of aerial devices	74
E.5	Tests	74
E.5.1	Periodic electrical tests	74
E.5.2	Mechanical test – Acoustic emission testing	80
E.6	Records	81
E.7	Repairing/refurbishing	81
E.8	Overriding safety devices	82
E.9	Care, maintenance and periodic inspection when insulating aerial devices are for other uses than live working	82
Annex F (informative)	Hydraulic depressurization (vacuum protection) (see 5.11.1 and 6.10.3)	83
F.1	General	83
F.2	In-line check valves	83
F.2.1	General	83
F.2.2	Testing the in-line check valves (typical test procedure – reference Figure F.1)	83
F.3	Atmospheric check valve assembly	84
F.3.1	General	84
F.3.2	Testing the atmospheric check valves (typical test procedure – reference Figure F.2)	85
Bibliography		87
Figure 1	– Specific terms	21
Figure 2	– Nomenclature	22
Figure 3	– Typical equipotential bonding arrangement	27
Figure 4	– Leakage current monitoring	30
Figure 5	– Example of temporary bypassing arrangement for chassis insulating system	32
Figure 6	– AC dielectric test before and after exposure to humidity (method A) – Typical test arrangement	40
Figure 7	– AC dielectric tests before and after exposure to humidity (method A) – Assembly diagram of the test piece to the guard electrodes	42
Figure 8	– AC dielectric tests before and after exposure to humidity (method A) – Constructional drawings for guard electrodes and parts	43
Figure 9	– AC dielectric tests before and after exposure to humidity (method A) – Constructional drawings for brass electrode and for insulating support parts according to test piece	44
Figure 10	– Details of electrode arrangement	46
Figure 11	– Test arrangement	46

Figure 12 – DC dielectric test before and after water soaking (method B) – Typical test arrangement	48
Figure 13 – Preparation of optical fibre cable test piece for test after the infliction of a gash	50
Figure 14 – Test of insulating basket or liner.....	51
Figure 15 – Test of the upper insulating system of devices with lower test electrode system.....	53
Figure 16 – Test of the upper insulating system of devices without permanently installed lower test electrode system.....	57
Figure 17 – Dielectric test for insulating insert/chassis insulating system	60
Figure 18 – Test of high electrical resistance component(s)	60
Figure E.1 – DC only test of the upper insulating system of devices without permanently installed lower test electrode system.....	78
Figure E.2 – DC only test of insulating lower boom insert or chassis insulating system	80
Figure F.1 – In-line check valve test for the insulating boom vacuum protection system	84
Figure F.2 – Atmospheric check valve assembly test for the insulating boom vacuum protection system.....	85
Table 1 – Values for AC dielectric tests of the upper insulating system of devices with lower test electrode system.....	54
Table 2 – Values for DC dielectric tests of the upper insulating system of devices with lower test electrode system.....	55
Table 3 – Dielectric test for aerial devices without lower test electrode system	58
Table C.1 – List and chronological order (where required) of type tests	67
Table D.1 – Classification of defects and associated requirements and tests	69
Table E.1 – Electrical test values for periodic electrical testing of insulating aerial devices with lower test electrode system for AC applications	75
Table E.2 – Electrical test values for periodic testing of insulating aerial devices without lower test electrode system for AC applications	75
Table E.3 – Electrical test values for periodic electrical testing of insulating components of aerial devices for AC applications	76
Table E.4 – Electrical test values for periodic electrical testing of insulating aerial devices with lower test electrode system for DC applications	76
Table F.1 – Allowable vacuum formation within hydraulic lines (adjusted for altitude)	86

INTERNATIONAL ELECTROTECHNICAL COMMISSION

LIVE WORKING – INSULATING AERIAL DEVICES FOR MOUNTING ON A CHASSIS

FOREWORD

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International Standard IEC 61057 has been prepared by IEC technical committee 78: Live working.

This second edition cancels and replaces the first edition published in 1991 and IEC TS 61813:2000. This edition constitutes a technical revision.

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

- a) general review of the requirements and test provisions;
- b) preparation of the elements of evaluation of defects, and general application of IEC 61318:2007;
- c) distinguishes between tests for hollow booms and those for foam filled booms;
- d) references ISO 16368 for particular mechanical tests;

- e) further information on vacuum protection and leakage current monitoring and a mandatory requirement that aerial devices for bare hand work be fitted with a permanently installed lower test electrode system;
- f) *controls* of high electrical resistance;
- g) reference to SAE for insulating hydraulic hoses;
- h) inclusion of IEC TS 61813 for care, maintenance and in-service testing of aerial devices with insulating booms.

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

FDIS	Report on voting
78/1182/FDIS	78/1183/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.

Terms defined in Clause 3 are given in italic print throughout this standard.

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- reconfirmed,
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- amended.

INTRODUCTION

This document covers *insulating aerial devices* for use at temperatures between –25 °C and +55 °C. Where aerial devices are for use in unusual atmospheric conditions (for example, higher or lower temperatures), other considerations may be appropriate and will be identified by the *manufacturer* both in the markings and instructions for use.

The products covered by this document are primarily intended to be used for live working or for work within the live working zone. It recognizes that a user may specify a product, or products complying with this document where there is a risk of accidental contact with live (energized) part(s). In such circumstances users are reminded that national or local regulations regarding maintaining of Minimum Approach Distances to live parts, or those obtained from IEC 61472 are to be applied. Annex A of this document gives advice and information.

The product covered by this document may have an impact on the environment during some or all stages of its life cycle. These impacts can range from slight to significant, be short-term or long-term, and occur at the global, regional or local level.

Except for a disposal statement in the Instructions for use, this document does not include requirements and test provisions for the *manufacturers* of the product, or recommendations to the users of the product for environmental improvement. However, all parties intervening in its design, manufacture, packaging, distribution, use, maintenance, repair, reuse, recovery and disposal are invited to take account of environmental considerations.

LIVE WORKING – INSULATING AERIAL DEVICES FOR MOUNTING ON A CHASSIS

1 Scope

This document is applicable to *insulating aerial devices* for mounting on a *chassis*, to be used for live working on electrical installations at nominal voltages above 1 000V r.m.s. AC in the range 45 Hz to 65 Hz and 1 500V DC.

The primary purpose of an aerial device is for work positioning of personnel. Other devices, such as jibs, may be fitted in order to assist the *operator* in performing the work.

This document also includes requirements and tests for the parts of the *chassis* influencing the performance of the *insulating aerial devices* to be used for live working.

When mounted on a *chassis*, the *insulating aerial device* becomes a component of a mobile elevating work *platform* (MEWP). Complementary requirements for the resulting MEWP are included in ISO 16368.

NOTE 1 In Europe, EN 280 instead of ISO 16368 is often used as reference for complementary requirements.

The products designed and manufactured according to this document contribute to the safety of users, provided they are used by skilled persons, in accordance with safe methods of work and the instructions for use.

NOTE 2 Any requirements that are in conflict with or are meant to be complementary to ISO 16368 are delineated herein.

Radial boom (digger) derricks are not covered by this document.

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 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

IEC 60212:2010, *Standard conditions for use prior to and during the testing of solid electrical insulating materials*

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 61318, *Live working – Conformity assessment applicable to tools, devices and equipment*

IEC 62237:2003, *Live working – Insulating hoses with fittings for use with hydraulic tools and equipment*

ISO 16368:2010, *Mobile elevating work platforms – Design, calculations, safety requirements and test methods*

ISO 13850, *Safety of machinery – Emergency stop function – Principles for design*

SAE J343, *Test and Test Procedures for SAE 100R Series Hydraulic Hose and Hose Assemblies*

SAE J517, *Hydraulic hose*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61318, ISO 16368 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

aerial device

insulating aerial device

any device, extensible, articulating or both, incorporating insulating components and which is primarily designed and used to position personnel at or near an electric potential different from that of earth

Note 1 to entry: An *insulating aerial device* may also be used to handle material if designed and equipped for that purpose.

Note 2 to entry: An *insulating aerial device* does not include a *chassis*. When an aerial device is mounted on a mobile *chassis* it becomes a component of a mobile elevating work *platform* (MEWP).

3.2

aerial device centre of gravity – horizontal

horizontal component of the distance from the axis of rotation to the centre of gravity of the aerial device in the *stowed position*

SEE: Figure 1

3.3

aerial device centre of gravity – vertical

vertical component of the distance above the mounting surface of the aerial device to the centre of gravity of the aerial device in the *stowed position*

SEE: Figure 1

3.4

aerial device mass

mass of the standard aerial device, less optional counterweights, accessories and auxiliary equipment

3.5

bare hand working

live working carried out in accordance with a method where the worker is electrically bonded to the energized parts on which live working is to be performed whilst being suitably isolated from surrounding parts which are at different potentials

[SOURCE: IEC 60050-651:2014, 651-21-07, modified – The definition has been modified for clarity.]

3.6

basket

bucket

totally enclosed type of *platform* which does not need guardrails or toe-guard

3.7

boom tip

furthest extremity of the *upper boom* from the *turntable* and the end of the *upper boom* to which the *platform* is attached

SEE: Figure 2

3.8

brittle material

fibreglass-reinforced plastic material or material that does not meet the requirements for *ductile material*

3.9

cab-axle dimension

distance between the back of the cab and the *rear axle centreline* of the *chassis* recommended for mounting the aerial device

SEE: Figure 1

3.10

centre of rotation location

distance from the centreline of the rear axle to the axis of rotation of the *turntable*

SEE: Figure 1

3.11

chassis

base on which the aerial device is mounted

3.12

chassis frame height

height from ground level to the top of the *chassis* frame rail

SEE: Figure 1

3.13

chassis insulating system

all dielectric components installed between the *chassis* and the upper insulating boom and designed to insulate the *chassis* should the portion of the aerial device between the upper insulating boom and this system contact a live part

SEE: Figure 2

Note 1 to entry: A *lower boom insulating insert* is a type of *chassis insulating system*.

3.14

conductive shield

guard ring

device used to shield the *lower test electrode system* from capacitive coupling

3.15

control

means by which operation of a function is effected

3.16

disruptive discharge

sparkover

flashover

passage of an arc following dielectric breakdown

Note 1 to entry: The term “sparkover” (in French “amorçage”) is used when a disruptive discharge occurs in a gaseous or liquid dielectric.

Note 2 to entry: The term “flashover” (in French “contournement”) is used when a disruptive discharge occurs over the surface of a solid dielectric surrounded by a gaseous or liquid medium.

Note 3 to entry: The term “puncture” (in French “perforation”) is used when a disruptive discharge occurs through a solid dielectric.

[SOURCE: IEC 60050-604:1987, 604-03-38]

3.17

ductile material

material that has a minimum elongation at failure of 10 % in a gauge length of 51 mm of a standardized test specimen

3.18

elbow

structure connecting the *upper boom* to the *lower boom*, about which one articulates relative to the other

SEE: Figure 2

3.19

elbow pin

horizontal pin about which the *upper boom* rotates relative to the *lower boom*

SEE: Figure 2

3.20

extensible boom aerial device

aerial device on which the length of the *upper boom* can be varied within pre-determined limits

EXAMPLE telescoping boom

3.21

fixed handling tool

tool that is mechanically mounted at the *boom tip* or *platform*

EXAMPLE *jib*, phase lifter

3.22

formally trained and qualified person

competent person possessing the appropriate practical and theoretical knowledge and having adequate skill and experience to enable them to perform the required duty, interpret the resultant information and from that information determine that the equipment is safe to use, and report the importance of any defect found or suspected in relation to the safety and continued use of the equipment

3.23**front overhang**

maximum distance of any part of the *aerial device* forward of the front bumper

SEE: Figure 1

3.24**front projection**

maximum distance of any part of the *aerial device* forward of the front axle centreline when stowed for travel

SEE: Figure 1

3.25**gradient control device**

corona ring

device at the upper end of an *insulating boom* that reduces electrical stress level(s) below that considered to be disruptive

3.26**guardrail system**

guard rail system

system of barriers intended to protect personnel from falling to lower levels

3.27**hot stick working**

live working carried out in accordance with a method where the worker remains at a specified distance from the energized parts and carries out the work by means of insulating sticks

[SOURCE: IEC 60050-651:2014, 651-21-05]

3.28**horizontal reach**

maximum distance reached from the centreline of the rotating *turntable* to the outer edge of the *platform*

SEE: Figure 1

3.29**instability**

condition of a MEWP in which the sum of the moments tending to overturn the MEWP is equal to or exceeds the sum of the moments tending to resist overturning

3.30**insulating boom**

insulating component of the extending structure denominated the *upper boom* and, where provided, the *lower boom insert*.

Note 1 to entry: ISO 16368 defines *extending structure*.

3.31**insulating glove working**

live working carried out in accordance with a method where the worker is in direct contact with an energized part and is electrically protected by electrical insulating gloves

[SOURCE: IEC 60050-651:2014, 651-21-06]

3.32

insulation gap

<upper boom> minimum length of the upper insulating system being the shortest distance in any boom position between conductive components at each end

SEE: Figure 1

3.33

insulation gap

<lower boom> minimum length of the *chassis insulating system*

SEE: Figure 1

3.34

jib

auxiliary arm at the *upper boom tip* to handle supplemental loads

SEE: Figure 2

3.35

liner

insert which fits inside the *platform*

SEE: Figure 2

Note 1 to entry: The *liner* may be insulating or conductive.

3.36

lower boom

structural member attached to a *turntable* or base, which supports the *upper boom*

SEE: Figure 2

3.37

lower boom cylinder

hydraulic cylinder which articulates the *lower boom*

SEE: Figure 2

3.38

lower boom insert

lower boom insulating insert

part of the *lower boom* made of high dielectric strength material

Note 1 to entry: The material is usually made of fibreglass reinforced plastic or equivalent.

3.39

lower boom pin

horizontal pin about which the *lower boom* is raised and lowered relative to the *turntable*

SEE: Figure 2

3.40

lower test electrode system

components installed on the aerial device that enable current monitoring across the insulating section

SEE: Figure 5c

3.41**lower boom travel up**

maximum angle reached by the *lower boom* measured above the horizontal axis passing through the *lower boom pin*

SEE: Figure 1

3.42**lower boom travel down**

maximum angle reached by the *lower boom* measured below a horizontal axis passing through the *lower boom pin*

SEE: Figure 1

3.43**lower control**

control mounted on the *chassis* (vehicle, *turntable* or *pedestal*) designed for the movement functions of the aerial device and other functions

SEE: Figure 2

Note 1 to entry: "Other functions" include operational checks, testing, or emergency rescue of *operator(s)*.

3.44**manufacturer**

person or entity with overall responsibility for the design, specification, fabrication, assembly and testing of the aerial device

3.45**model**

manufacturer's designation for the specified aerial device

3.46**operator**

person trained, authorized, and engaged in the operation of the *aerial device*

3.47**outrigger**

structural member which, when properly extended or deployed on firm ground, assists in stabilizing the MEWP

SEE: Figure 2

3.48**outrigger control**

control for operating the *outrigger(s)*

SEE: Figure 2

3.49**outrigger height**

distance from ground level to the bottom of retracted *outriggers*

SEE: Figure 1

3.50**outrigger penetration**

distance below ground level which the *outriggers* can reach when fully extended

SEE: Figure 1

3.51

outrigger spread

distance between the outer edges on fixed pads, or between pins on pivoted pads, of opposite *outriggers* resting on level ground

SEE: Figure 1

3.52

outrigger spread

distance between the outer edges on fixed pads, or between pins on pivoted pads, of opposite *outriggers* when fully extended

SEE: Figure 1

3.53

overall length

maximum distance of any part of the aerial device or the *chassis* between the front and the back in the *stowed position*

SEE: Figure 1

3.54

override

means of disabling or bypassing normal control and safety devices for emergency operation, maintenance or testing

3.55

pedestal

stationary base of the *aerial device* that supports the *turntable*

SEE: Figure 2

3.56

platform

component of an aerial device such as a *basket*, stand, or equivalent that carries personnel and their tools

SEE: Figure 2

3.57

platform capacity

component of *rated load capacity* consisting of the mass of personnel and all items carried on or in the *platform* such as liner, tools, equipment, etc.

3.58

platform pin

axle about which the *platform* moves relative to the *upper boom*

SEE: Figure 2

3.59

rated load capacity

maximum vertical load which can be lifted by the aerial device through the specified range of boom elevation and extension with specified options installed and in consideration of stability requirements

Note 1 to entry: The rated load capacity is generally considered as platform capacity + supplemental capacity.

3.60**rated platform height of the MEWP**

nominal distance at maximum elevation from the bottom of the *platform* to the ground when mounted on a reference *chassis* height of 1 m

SEE: Figure 1

3.61**rated voltage of the aerial device** U_r

maximum use voltage of the aerial device

Note 1 to entry: For AC, the rated voltage corresponds to the maximum r.m.s. phase to phase voltage of a three-phase system.

Note 2 to entry: For DC, the rated voltage corresponds to the maximum voltage between positive and negative poles of a system.

3.62**rear axle centreline**

location of the combination moment equivalent for the centrelines of one, two, three or more rear axles

SEE: Figure 1

3.63**rear projection**

maximum distance of any part of the *aerial device* behind the *rear axle centreline* when stowed for travel

SEE: Figure 1

3.64**rear overhang**

maximum distance of any part of the *aerial device* behind the rear bumper

SEE: Figure 1

3.65**stabilizer****outrigger****jack****suspension locking device****extending axle****torsion bar**

any device or system used to stabilize a MEWP by supporting and/or levelling the complete MEWP or the extending structure

SEE: Figure 2

[SOURCE: ISO 16368:2010, definition 3.33]

3.66**stowed position**

configuration as defined by the *manufacturer* where the MEWP is positioned for travel

3.67**supplemental capacity**

component of *rated load capacity* which may be fixed directly to the boom(s) or to load carrying attachments on the *aerial device*

3.68

travel height

overall height from ground level to the highest point on the *aerial device* when the MEWP is in a *stowed position*

SEE: Figure 1

3.69

turntable

rotating base of the *aerial device* that supports the booms

SEE: Figure 2

3.70

turntable rotation

turntable slewing

range of *turntable* rotation, in either direction, expressed as continuous or non-continuous, specified in angular degrees

SEE: Figure 1

3.71

upper boom

primary insulating structural member attached to the *lower boom*, or to an extendable structure and which supports the *platform*

SEE: Figure 2

3.72

upper boom cylinder

hydraulic cylinder which articulates the *upper boom*

SEE: Figure 2

3.73

upper boom drive mechanism

means, such as linkage, cables, sheaves and gears, used to produce *upper boom* articulation

SEE: Figure 2

3.74

upper boom travel up

maximum angle reached by the *upper boom* measured above a horizontal axis passing through the *elbow pin* at its maximum height

SEE: Figure 1

3.75

upper boom travel down

maximum angle reached by the *upper boom* measured below a horizontal axis passing through the *elbow pin* at its maximum height

SEE: Figure 1

3.76

upper (platform) control

control located in or beside the *platform*, and designed for the operational functions of the aerial device and other functions

SEE: Figure 2

Note 1 to entry: Other functions include *control* of the *jib* and winch.

Note 2 to entry: There may be one or more controls, each operating different functions.

3.77

wheel base

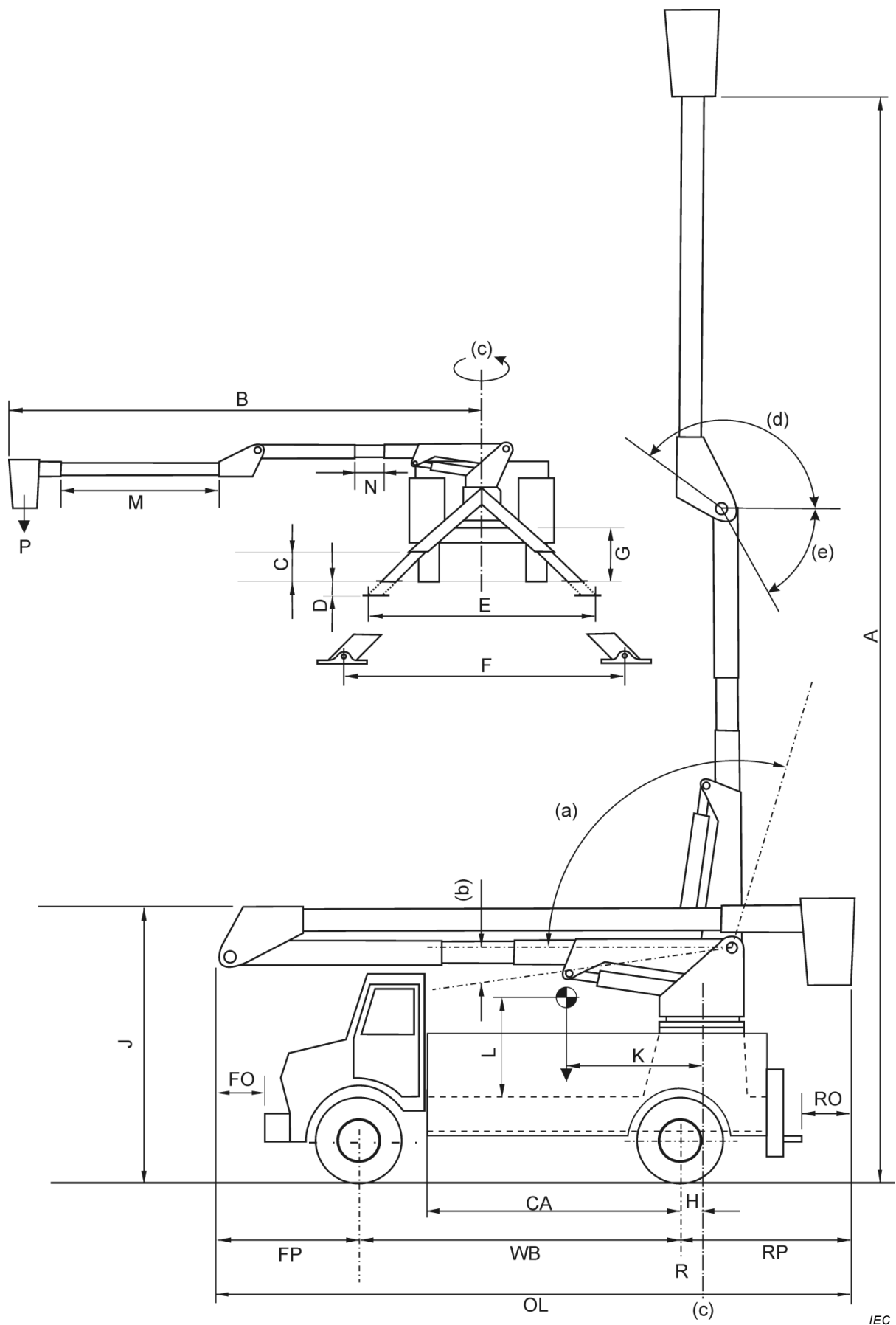
distance between the front and *rear axle centrelines* of the *chassis*

SEE: Figure 1

4 Specific terms and nomenclature

For the purposes of clarity and to prevent possible confusion between *manufacturers* and users, Figures 1 and 2 identify the standard terms to be used when designing, specifying and marking aerial devices with insulating booms for live working.

Clause 3 defines these standard terms.



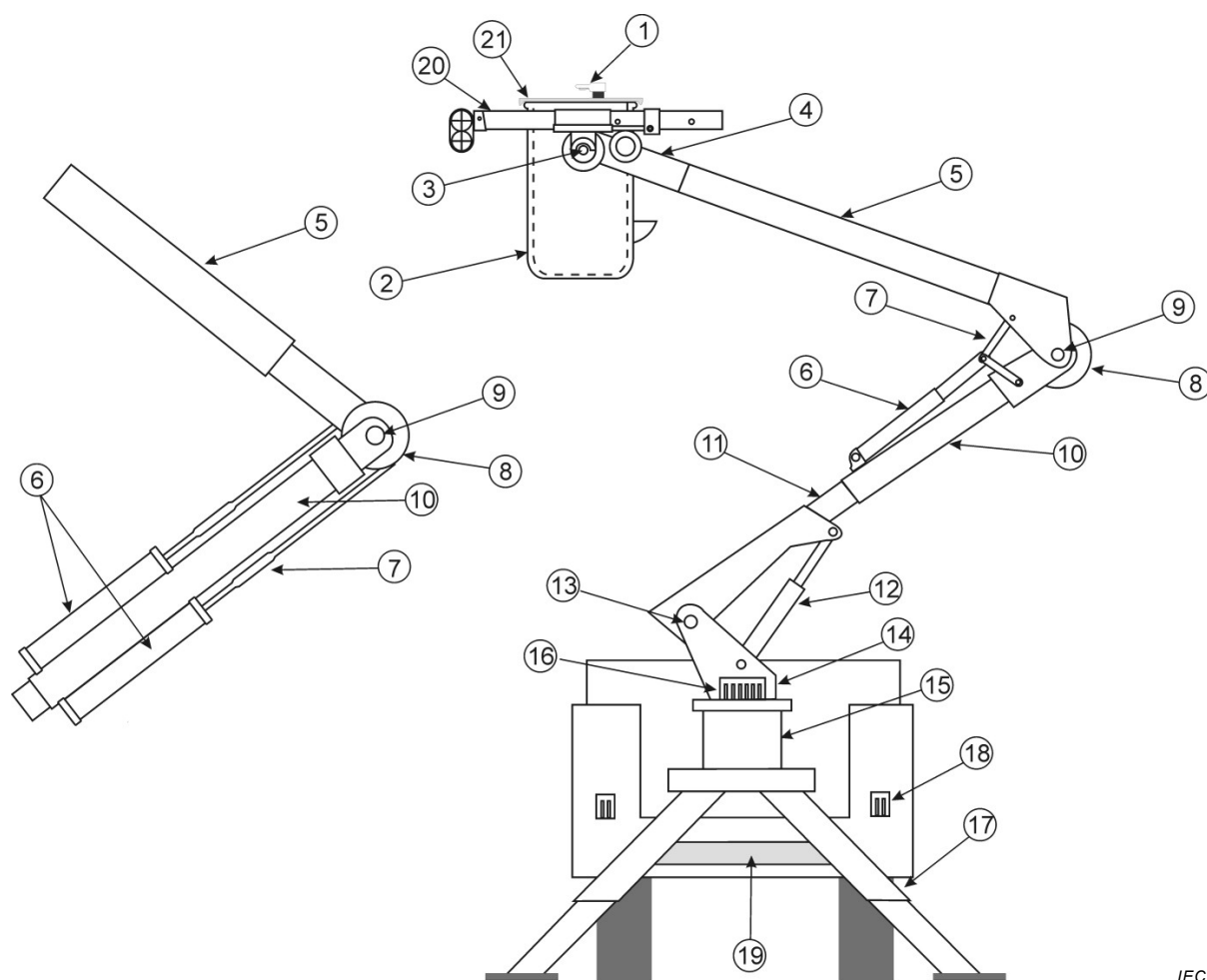
IEC

Key

A	rated platform height (of the MEWP)	M	insulation gap (upper boom) ^a
B	horizontal reach	N	insulation gap (lower boom) ^a
C	outrigger height	OL	overall length
CA	cab-axle dimension	P	rated capacity
D	outrigger penetration (below ground level)	R	centreline of rear axle(s)
E	outrigger spread (at ground level)	RO	rear overhang
F	outrigger spread (at maximum extension)	RP	rear projection
FO	front overhang	WB	wheel base
FP	front projection	(a)	lower boom travel up
G	chassis frame height	(b)	lower boom travel down
H	centre of rotation location	(c)	centre of turntable rotation
J	travel height (stowed) of the MEWP	(d)	upper boom travel up
K	aerial device centre of gravity – horizontal	(e)	upper boom travel down
L	aerial device centre of gravity – vertical		

Minimum insulation gaps are not determined by exposed insulating materials. Internal conductive components may determine these measurements (see 3.32 and 3.33).

Figure 1 – Specific terms



IEC

Key

1	upper platform controls	8	elbow	15	pedestal
2	platform	9	elbow pin	16	lower controls
3	platform pin	10	lower boom	17	outrigger
4	boom tip	11	lower boom insert	18	outrigger controls
5	upper boom	12	lower boom cylinder	19	stabilizer
6	upper boom cylinder	13	lower boom pin	20	jib
7	upper boom drive mechanism	14	turntable	21	liner

Figure 2 – Nomenclature

5 Requirements

5.1 Controls

5.1.1 Activation and operation

For the purpose of this document, the corresponding requirements of ISO 16368 do not apply. *Control* activation and operation of the devices covered by this standard shall fulfil the following requirements.

Aerial devices shall be provided with *controls* such that all functions can only take place while the corresponding *control* is being actuated.

As a means to prevent inadvertent or unintentional operation, *upper boom* positioning *controls* shall require the use of an enabling or interlock device which shall be engaged prior to operating the *control* itself and which shall be continually maintained during the use of the *control*. The enabling or interlock device and *control* shall return to the locked or neutral position when released by the *operator*.

Based on the design and type of aerial device and the *control* panel arrangement employed, *controls* can move in a direction that corresponds logically to the movement function they *control* recognizing that it is not always possible in all design configurations.

Controls systems shall take into account any field effects associated with operating in a live working environment including those associated with bonding of platforms when performing *bare hand working*.

Controls shall be positioned to avoid danger to the *operator* from moving parts of the unit.

Controls shall be clearly marked to identify their function and protected from damage.

5.1.2 Duplicate controls

For the purpose of this document, the corresponding requirements of ISO 16368 do not apply. Duplicate *controls* of the devices covered by this document shall fulfil the following requirements.

As a minimum, aerial devices shall have two sets of *controls*. One set of controls (*upper controls*) shall be located in or beside the *platform* and readily accessible to the operator. *Aerial devices* which have two *platforms* shall have the *controls* positioned to provide operation to be accomplished from either *platform* with reasonable ease and without the need to disengage any fall protection device which an operator may be wearing.

NOTE A distance of 0,8 m from the secondary platform to any control device is considered adequate for "reasonable ease".

A duplicate set of *controls* (*lower controls*) shall be provided and located such that an *operator* of the *lower controls* cannot be placed in the electrical path between the *aerial device* and the ground.

A selector between upper and *lower controls* shall be provided at the *lower control* station. When engaged in the *lower control* position, the *lower controls* shall *override* the *upper controls* for all powered functions of the extending structure and winch (if equipped) with the exception of *control* of the *jibs* and other non boom positioning functions.

Unless the *control* system is defective, a *control* at the *platform* which becomes activated shall not prevent the *lower controls* from being selected and functioning normally.

If movement can be controlled from additional *control* stations, *control* shall be possible from only one pre-selected *control* station. The *lower controls* shall *override* all additional *controls*.

5.1.3 Emergency stop

For the purpose of this document, the corresponding requirements of ISO 16368 do not apply. Emergency stop of the devices covered by this document shall fulfil the following requirements.

A means shall be provided at each *control* station to effect an emergency stop of all functions according to ISO 13850. The function shall not require continuous actuation for a stop condition. It shall be permanently marked to identify its function.

At the *lower controls*, the *override control* may be used as the emergency stop. In such a case, it shall perform this function consistent with the above paragraph.

5.1.4 Control of outriggers

For the purpose of this document, the corresponding requirements of ISO 16368 do not apply. The *outrigger control(s)* shall fulfil the following requirements.

The *control(s)* shall be located so that its *operator* has a clear unobstructed view of the *outrigger* being operated.

The *control(s)* shall be guarded against inadvertent activation. A selector or other means is acceptable.

The system shall be designed to prevent:

- simultaneous operation of outriggers and aerial device;
- retraction of the outriggers unless the aerial device is in its *stowed position*;
- operation of the aerial device unless the outriggers are deployed (unless the aerial device has been designed and tested for use inside a restricted work envelope without the use of outriggers).

An *override* of these functions can be provided. When provided, the *override* mode of operation shall disable automatically.

5.1.5 Monitoring of radio and optical fibre controls

A process shall be provided in the case of radio or optical fibre *controls* to verify communication between the sender and receiver.

5.1.6 High electrical resistance upper control system(s)

There is no requirement for the aerial device to be provided with high electrical resistance upper *control* system(s). Such systems may reduce electrical contact hazard at the platform. It is not part of the primary insulating system and is excluded when determining the *rated voltage of the aerial device*. When identified as a high electrical resistance system, it shall be electrically tested to confirm its performance (see 6.7.3.2 for the test method).

5.2 Failure of the source of power

All movement shall cease should there be a failure of the source of power. On starting, or on restoration of power after failure of the power supply, no movement shall occur unless there is a deliberate action by the *operator*.

5.3 Restoration of power after failure

An overriding system shall be provided (e.g. hand pump, secondary power unit, etc.), in an easily accessible position, to ensure that, in the event of failure of the main power supply or the *operator* becoming incapacitated, the work *platform* can be returned to a position from which it is possible to leave it without danger, taking into account the need to manoeuvre it clear of obstructions.

5.4 Boom travel protection

A means shall be provided to prevent damage to the boom(s) and work platform(s) whilst in the *stowed position* from vibrations during travel (see 4.4.6 of ISO 16368:2010).

5.5 Chassis inclination

For the purpose of this document, the requirements of 4.3.2 of ISO 16368:2010 apply except for the requirements regarding MEWPs of type 2 and type 3 defined in ISO 16368:2010.

A device shall be provided to indicate whether the inclination of the *chassis* is within the limits permitted by the *manufacturer*. This device shall be protected against damage and accidental change of its setting.

For aerial devices with *stabilizers* intended for levelling, an indication of inclination of the *chassis* (e.g. inclinometer) shall be clearly visible from each *control* position of the *stabilizers*.

5.6 Locking pins

For the purpose of this document, the corresponding requirements of ISO 16368:2010 do not apply in their entirety.

Any locking pins shall be secured against unintentional disengagement and loss.

5.7 Electrical requirements

5.7.1 Insulating systems

All components crossing the insulating sections of the aerial device shall have electrical insulating characteristics consistent with the design voltage rating of the boom, and when provided, of the *chassis insulating system*.

NOTE The use of insulating tubes and rods complying with IEC 60855-1 or IEC 61235 in the design of such components will contribute to fulfilling this requirement.

The insulating system shall maintain the electrical insulating characteristics in all working boom configurations as defined by the *manufacturer*.

All components of the insulating system shall be designed to prevent moisture and contaminants being trapped (or confined) across an insulating section.

The limits of the insulating sections shall be marked on the external surface and be clearly visible to the *operator*. Sections of the aerial devices marked as insulating shall be clear of external and internal conductive components.

5.7.2 Insulating booms (including lower boom insulating insert / chassis insulating system)

5.7.2.1 Insulating materials

Insulating materials used to manufacture the insulating booms, and *lower boom insulating insert* if provided, shall fulfil the requirements of this document.

5.7.2.2 Open hollow booms

Open hollow booms shall be manufactured in such a way that cleaning, drying and inspection of the inside are possible.

NOTE An endoscope or any other camera system can be used to permit the internal survey of the boom.

5.7.2.3 Sealed hollow booms

Sealed hollow booms shall be equipped with a system to prevent the accumulation of dust and moisture.

NOTE An example is where the boom is filled with inert gas in which case the difference in pressure between the gas and the atmosphere is measured continuously to ensure the efficiency of the sealing.

5.7.2.4 Foam filled booms

Where applicable, foam filled booms shall meet the requirements of IEC 60855-1.

The foam filling shall be bonded to the wall of the boom. The foam filling shall be free of voids, separations, cracks or other defects.

5.7.3 Non-conductive/insulating hydraulic hoses and lines

Non-conductive/insulating hoses shall comply with the tests and test procedures of SAE J343 and the general, dimensional and performance specifications of SAE J517 for 100R7 hoses and/or 100R8 hoses.

Non-conductive/insulating hoses that are installed external to the boom and shunt an insulating section shall, at the request of a user, provide additional performance requirements by conforming with: SAE J343 and SAE J517 for 100R7 hoses and/or for 100R8 hoses, plus an additional dielectric test specified in 5.3.1.2 and 5.3.1.3 of IEC 62237:2003, and an additional test after the infliction of a cut as specified in 5.3.1.4 of IEC 62237:2003.

The external surface of non-conductive/insulating hoses shall be clearly identified to indicate that they are non-conductive or insulating.

Fluid used in hoses and lines shall have electrical characteristics that do not reduce the electrical integrity of the insulating system.

Non-conductive/insulating pneumatic lines shall have electrical characteristics equivalent to non-conductive/insulating hydraulic hoses.

Manufacturer shall indicate to the users the standard(s) to which the hoses comply in terms of dielectric performance.

5.7.4 Insulating fixed handling tools

Boom tip, *jibs* and/or other handling tools used for handling energized conductors and apparatus, shall be rated at the appropriate line voltage to insulate the *boom tip*.

Insulating *fixed handling tools* shall be marked for the use.

NOTE The use of insulating tubes and rods complying with IEC 60855-1 or IEC 61235 in the design of *jibs* will contribute to fulfilling this requirement.

5.7.5 Insulating optical fibre cables

Optical fibre cables shall have electrical characteristics equivalent to insulating hydraulic hoses.

Optical fibre cables that form part of the insulating system shall be insulating and tested in accordance with 6.6.2.4.2.

When optical fibre cables are installed outside the boom and cross an insulation gap, they shall also be tested in accordance with 6.6.2.4.3.

5.7.6 Equipotential bonding

Aerial devices designed for *bare hand working* (see Annex A) shall have equipotential bonding of all conductive components at the *platform* end (see Figure 3).

Conductive components may include *platform* mounted hardware, all *controls*, *control* valves, tool connections, engine kill switch, *gradient control device*, conductive liner, etc.

Manufacturer shall identify, in the instructions for use, the *boom tip* bonding points to be employed for test purposes and, where the aerial device is to be utilized for bare hand work, the *boom tip* bonding points to be employed for use.

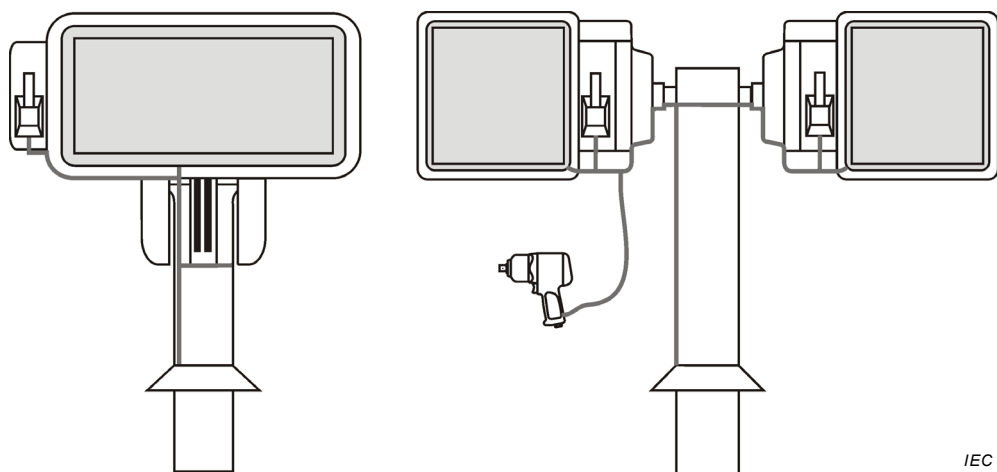
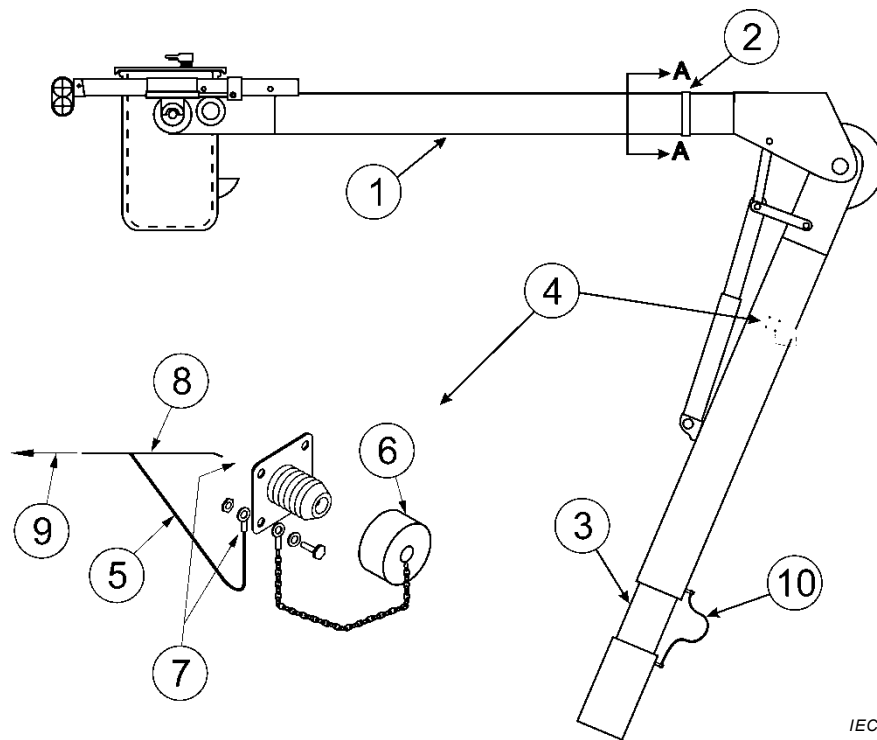


Figure 3 – Typical equipotential bonding arrangement

5.7.7 Lower test electrode system

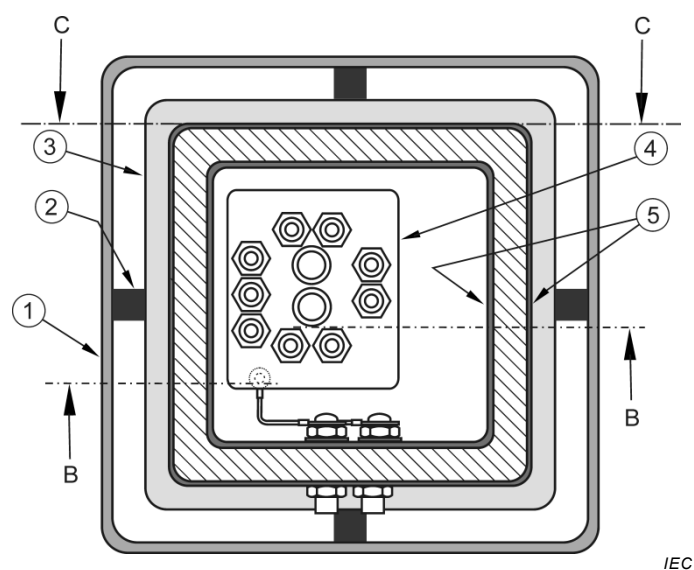
Aerial devices designed for *bare hand working* shall be equipped with a permanently installed *lower test electrode system*. An example of a *lower test electrode system* is illustrated in Figure 4.



Key

- | | |
|---|--|
| 1 upper boom | 6 weatherproof cap |
| 2 leakage current monitoring band | 7 solder |
| 3 insulating insert | 8 insulated conductor or multiple conductor cable (multi-position switch required) |
| 4 meter receptacle – shorted when not in use | 9 to monitoring band |
| 5 metal shielding connected between the meter receptacle and the metal boom | 10 shunt |

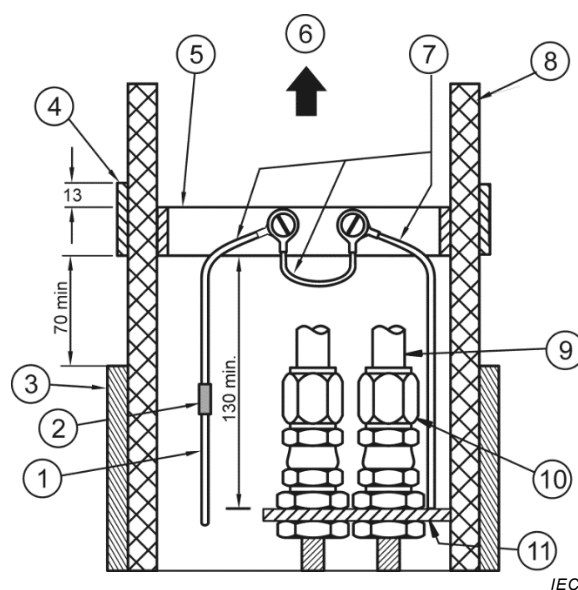
Figure 4a – Typical Lower Test Electrode System (conductive shield omitted)



IEC

Key

- | | | | | | |
|---|---------------------------|---|-------------------------------|---|----------------------------------|
| 1 | Conductive shield | 3 | Conductive (metal) boom | 5 | leakage current monitoring bands |
| 2 | Plastic insulating blocks | 4 | hydraulic hose metal bulkhead | | |

Figure 4b – Section AA of Figure 4a – Layout of interconnection*Dimensions in millimetres*

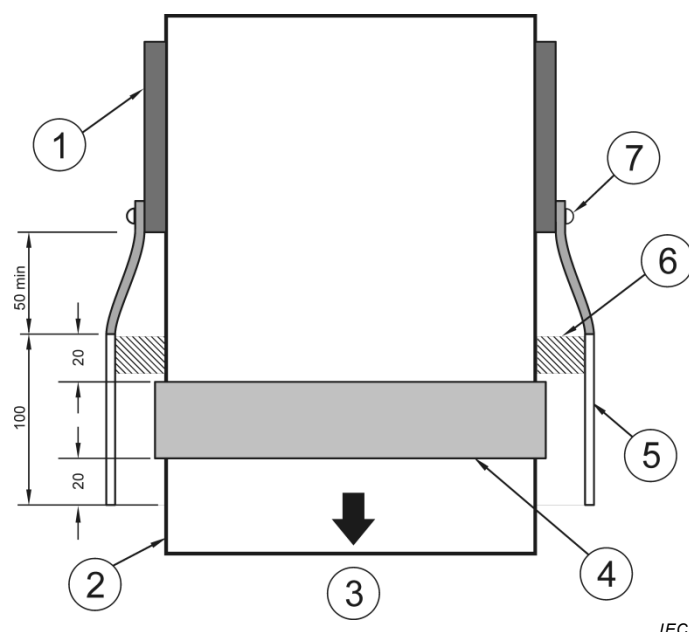
IEC

Key

- | | | | |
|---|---|----|---|
| 1 | coaxial cable from receptacle | 7 | insulated wires |
| 2 | fold back metal shielding approximately 50 mm from terminal and insulate exposed end of shielding | 8 | insulating boom |
| 3 | conductive (metal) boom | 9 | hydraulic hoses |
| 4 | outer leakage current monitoring band with leading edge closer to the boom tip than inner | 10 | bulkhead fittings |
| 5 | inner leakage current monitoring band | 11 | hydraulic hose metal bulkhead to be electrically insulated from metal portion of boom |
| 6 | to platform | | hydraulic hoses connected to the non-insulating side of the bulkhead shall be non-conductive and a minimum length of 150 mm |

Figure 4c – Section BB of Figure 4b – Details of lower test electrode assembly (conductive shield and plastic blocks omitted)

Dimensions in millimetres



Key

- | | | | |
|---|---|---|-------------------|
| 1 | conductive (metal) boom | 5 | conductive shield |
| 2 | insulating boom | 6 | insulating blocks |
| 3 | to platform | 7 | fixings |
| 4 | outer leakage current monitoring band with leading edge closer to the boom tip than inner | | |

Figure 4d – Section CC of Figure 4b – Example of conductive shield

Figure 4 – Leakage current monitoring

Aerial devices which are equipped with a system for measuring and monitoring the leakage current shall have conductive bands permanently installed one on the inside and one on the outside surfaces of the insulating portion of the *upper boom* for the purpose of measuring and monitoring leakage current.

The conductive leakage current monitoring bands shall be 70mm minimum from the metal portion of the lower end of the insulating *upper boom*. Distance between the inner leakage current monitoring band and the hose bulkhead shall be 130 mm minimum to provide electrical shielding of metal hose couplings. Outer test band shall be extended towards the *platform* end (*boom tip*) by 13 mm minimum past the leading edge of the inner current monitoring band in order to avoid discharges due to negative corona on the inside surface of the boom during testing.

All fibre optic lines crossing the insulating portion of the *upper boom* shall have conductive couplings at the common point (bulkhead) to enable connection of the inside and outside of each line to the current monitoring circuit. On fibre optic lines sanctioned by test to be dielectrically sound and to not wick water, the leakage current monitoring circuit may be connected to the outer sheathing only.

All hydraulic and pneumatic lines crossing the insulating portion of the *upper boom* shall have conductive couplings at a common point, which can be at a bulkhead, which connect the inside and outside of each line to the current monitoring circuit. For an example of a layout for hollow booms, see Figure 4b and Figure 4c.

All other components that cross the insulating section of the *upper boom*, such as levelling rods, shall connect to the common point (bulkhead) that enables leakage current monitoring.

Provisions shall be made for the isolation of individual components to identify each leakage current monitoring path. A shielded lead(s) to the meter receptacle shall provide the leakage current monitoring path from the lower bulkhead of the *upper boom*.

In the case of hollow boom, access shall be provided to the bulkhead and to the electrical connections inside the boom.

Insulating aerial devices equipped with *gradient control devices* shall have the *lower test electrode system* equipped with a *conductive shield* (See Figure 4d) to reduce the capacitive coupling effect and to improve indication of actual leakage current across the insulating system.

The leakage current monitoring system should be designed so that it is not damaged due to surges produced by make or break of contact.

5.7.8 Corona effect

No damage to insulating materials (surface tracking, erosion, etc.) shall occur due to corona effects.

5.7.9 Gradient control devices

Where required, aerial devices shall be equipped with a *gradient control device(s)* on the *platform* end of the insulating section of the *upper boom*.

The *gradient control device(s)* shall be designed to prohibit installation in an orientation not intended by the *manufacturer* or permanently marked to identify the *manufacturer's* intended orientation.

All conductive parts, including *platform* fittings shall be bonded to the *gradient control device*.

No conductive component shall extend down the insulating section of the boom past the *gradient control device(s)* in any boom position.

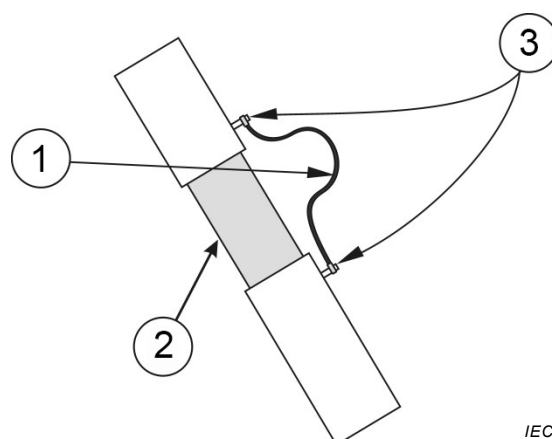
NOTE 1 The necessity of a *gradient control device* on aerial devices is determined by the type test.

NOTE 2 Experience indicates that gradient control device(s) are generally required on aerial devices with a rated voltage above 138 kV.

5.7.10 Chassis insulating system bypass

Aerial devices shall be provided with a means to bypass the *chassis insulating system*.

Figure 5 illustrates an example of a *chassis insulating system* (in this case a *lower boom insulating insert*) and a means of bypassing.



IEC

Key

- 1 shunt
- 2 chassis insulating system
- 3 stainless steel stud with 25 mm of thread exposed

Figure 5 – Example of temporary bypassing arrangement for chassis insulating system

5.7.11 Chassis earthing system

Aerial devices designed for *bare hand working* or at the user's request shall be equipped with a means of earthing the *chassis* and subframe. The means shall be agreed between the user and the *manufacturer* and shall be appropriately rated for the prospective short circuit current for the system to be worked upon.

Where an earthing reel is provided, the resistance between the earth clamp and the bonding jumper shaft connection shall be less than 0,002 Ω .

The minimum requirement should be an earthing stud which is suitably located and easily accessible on the aerial device, complete with cable and earth clamp having a minimum fault current rating of 43 kA for 15 cycles.

5.8 Particular mechanical requirements

5.8.1 Structural design

Structural elements of the aerial device which support the platform, the *platform* itself, and material carrying attachments shall be so designed that they fulfil the requirements and tests included in this document.

The general structural design shall provide against failure by yielding. The general structural design shall provide against failure by fatigue fracturing.

For *ductile materials*, the design stress shall not be more than 50 % of minimum yield strength of the material.

For *brittle materials* and fibreglass reinforced plastic (including insulating booms, tubes, rods and *jibs*), the design stress shall not be more than 20 % of the minimum ultimate strength of the material.

For chains, wire rope assemblies and components rated according to ultimate strengths, the design loads shall not be more than 20 % of the ultimate strength.

5.8.2 Stability

The stability requirements and the related tests of 5.1.4.5 of ISO 16368:2010 (Vehicle-mounted overload and stability check tests) shall apply. There shall be no *instability*.

5.8.3 Wind speed

The wind forces of 4.2.2.3 of ISO 16368:2010 shall apply.

5.9 Speeds of the extending structure

The requirements of ISO 16368:2010, 4.4.5 (Speeds of extending structure) shall apply.

5.10 Load sensing

There are no load sensing requirements for the products covered by this document.

NOTE The use of electrical load sensing as safeguarding against overload and instability may create new hazards for an *insulating aerial device* whereas non-electrical load sensing may not meet performance requirements for load sensing as specified in ISO 16368:2010, 4.4.

5.11 Requirements for the hydraulic system

5.11.1 Hydraulic depressurization (vacuum protection)

Aerial devices having hydraulic lines that cross the insulating boom, where the maximum height of the oil column between the oil reservoir and the *boom tip* is greater than 11 m (36 ft), shall have a method to prevent and/or limit a partial vacuum formation within all such lines resulting in a reduction in dielectric strength that could produce an electrical breakdown. The maximum allowable partial vacuum formation in any line shall not result in an absolute pressure less than 80 % of the ambient atmospheric pressure within the insulating portion of the boom.

NOTE As an example, such a device could be a valve preventing gravity from drawing the fluid out of the line, and/or valves that open to atmosphere when the absolute pressure inside the lines normally containing fluid in an evacuated area is below 80 % of the ambient atmospheric pressure (See Annex F).

Suitable access to the vacuum protection components for testing and service shall be provided. The location of the vacuum protection components shall be identified in the instructions for use.

Manufacturers shall provide detailed information in the aerial device's instructions for use for performing periodic inspections and servicing of the vacuum protection system. The instructions shall provide values for hydraulic vacuum protection components.

5.11.2 Hydraulic pressure rise

A means shall be provided to limit pressure rise due to factors such as thermal expansion of hydraulic fluid and leakage that could result in stresses that exceed the yield strength of the material.

5.11.3 System protection

This subclause augments the requirements of ISO 16368:2010, 4.10.2.

Where the operation of the aerial device is accomplished by hydraulic means, the system shall be equipped with appropriate devices to prevent in the event of hydraulic line failure motion of the *platform(s)* or material lifting device, or both.

This requirement does not apply to properly guarded metallic tubing installed between a holding device and the cylinder.

If lock valves are used they shall close automatically to prevent liquid leaving the cylinders. They shall be:

- integral with the cylinder, or
- directly and rigidly flange-mounted, or
- placed close to the cylinder and connected to it by means of rigid pipes (as short as possible), having welded or flanged connections and being calculated in the same way as the cylinder.

Pilot operated *control* valves shall be so designed and installed that they fail to safety (i.e. stop the corresponding movement) in the event of power failure.

Other types of fittings such as compression fittings or flared pipe fittings are not permitted between the cylinder and the lock valve.

Where the operation of the aerial device is accomplished electrically, the system shall be designed to prevent motion in the event of power loss.

5.11.4 Overriding safety devices

Procedures and equipment for overriding safety devices shall be designed to provide safety to personnel and minimize the possibility of an unsafe condition (see ISO 16368:2010, 4.11.6).

See E.8 for overriding situations.

5.11.5 Pressure limiting device

The requirements of ISO 16368:2010, 4.9.1 (Pressure limiting device), shall apply.

5.11.6 Bursting strength – hoses and fittings

All fittings and hoses in load-holding circuits shall have a minimum bursting strength of four times the operating pressure for which the system is designed. This requirement augments the requirement of ISO 16368:2010, 4.9.3.

Other hoses and fittings shall have a minimum bursting strength of three times the operating pressure for which the system is designed.

5.11.7 Fluid level indicators

The requirements of ISO 16368:2010, 4.9.8 (Fluid level indicators), shall apply.

5.11.8 Fluid cleanliness

The requirements of ISO 16368:2010, 4.9.9 (Fluid cleanliness), shall apply.

5.12 Requirements for the platforms

5.12.1 Platform security

Platforms shall be designed or secured to withstand vibration and shock loading during travel.

5.12.2 Platform levelling

For the purpose of this document, the requirements of ISO 16368:2010, 4.6.1 do not apply.

The *platform* shall be provided with a positive levelling system to prevent overturning.

NOTE The system can be mechanical (e.g. rods, cables and/or chains), hydraulic or others according to national or regional regulations.

5.12.3 Guardrail system

Platforms other than *baskets* shall include a *guardrail system*. The *guardrail system* shall comply with 4.6.3, 4.6.5 and 4.6.7 of ISO 16368:2010.

5.12.4 Baskets

5.12.4.1 General

Baskets shall be of a minimum height of 0,9 m. This recognizes national variations in physical stature of persons.

5.12.4.2 Non-insulating baskets designed for use with insulating liners

Baskets classified as non-insulating shall be constructed from non-conductive materials and clearly identified as non-insulating. They shall not have drain holes or access openings.

Insulating liners for these *baskets* shall be constructed from non-conductive materials and tested in accordance with 6.6.3.

The *liner* shall be supported by the inside bottom surface of the *basket*.

5.12.4.3 Non-insulating baskets designed for use without liners

The *basket* shall be identified as non-insulating and not for use with insulating liners.

Non-insulating *baskets* may be constructed from conductive or non-conductive materials. These non-insulating *baskets* may have drain holes and/or access openings.

5.12.4.4 Insulating baskets

Insulating *baskets* shall be constructed from non-conductive materials and shall have no drain holes or access openings. Insulating *baskets* shall be tested in accordance with 6.6.3.

5.12.5 Personnel safety attachments (and attachment for fall protection)

The requirements of ISO 16368:2010, 4.6.4 shall apply.

The *manufacturer* will clearly indicate which system(s) of fall protection has been designed for, i.e. fall arrest and/or fall restraint and the performance criteria for the particular system(s).

5.13 Marking

Each aerial device shall be marked with the following minimum permanent items of marking:

- *manufacturer's* name or trademark;
- type reference (*model*);
- serial number;
- year and month of manufacture;
- rated *platform* height of the MEWP;
- *rated voltage of the aerial device* in either "AC" or "DC" (or both if the aerial device has a dual voltage rating);
- *control* system(s) of high electrical resistance when identified as such by the *manufacturer*;

- all *controls* shall be clearly marked to identify their function;
 - ambient temperature range for operation of the aerial device to maintain structural integrity (if required);
 - marking specifying the number of *platforms* that the aerial device is rated and tested for;
 - rated wind speed (not necessarily on the device except if special);
 - rated *platform capacity* specified on a firm and level surface:
 - per *basket*,
 - total (*both baskets and jibs*);
 - material handling capacity chart (where *jib* and winch are fitted) located to be visible by an *operator* standing in *basket* in which the *jib/winch controls* are installed;
 - symbol IEC 60417-5216:2002-10 – Suitable for live working; double triangle (see Annex B);
- NOTE The exact ratio of the height of the figure to the base of the triangle is 1,43. For the purpose of convenience, this ratio can be between the values of 1,4 and 1,5.
- number of the relevant IEC standard immediately adjacent to the symbol with year of publication (four digits), (IEC 61057:2017).

The marking shall be durable, clearly visible and legible to a person with normal or corrected vision without additional magnification. The marking shall be placed in a position remote from the strip indicating the positions of internal metal parts.

No marking shall adversely affect the performance of insulating parts.

5.14 Instructions for use

Each *insulating aerial device* covered by this document shall be supplied with the *manufacturer's* written instructions for use and care and shall include as a minimum:

- operating instructions which give details for safe use;
- characteristics of required hydraulic non-conductive or insulating fluid(s);

When the non-conductive or insulating hoses with fittings are to be used at low temperatures, user and manufacturer shall make sure that information on adequate non-conductive or insulating fluid(s) are included.

- instructions for cleaning, storage and transportation;
- instructions for periodic testing and possible repair;
- recommendations and procedure to *override* safety devices during testing, maintenance or repair.

5.15 Dimensions and mass

The *manufacturer* shall record the dimensions in Figure 1 and the *aerial device mass* and this information shall be available on request to the user.

6 Tests

6.1 General

This document provides testing provisions to demonstrate that the products comply with the requirements of Clause 5. These testing provisions are primarily intended to be used for type testing for validation of the design input. Where relevant, alternative means (calculation, examination, tests, etc.), are specified within the test subclauses for the purpose of products having completed the production phase.

Annex C gives the list of type tests and specifies the chronological order, when required.

Unless otherwise specified, for all tests, the tolerance on the lengths shall be ± 10 mm.

The fluid used for the tests shall meet the characteristics specified by the *manufacturer* in the instructions for use (see 5.14). The references of fluid used for the tests shall be recorded with the test results.

For final testing of completed aerial devices, mechanical tests shall be completed before the electrical tests.

6.2 Visual and dimensional check

A visual inspection shall be carried out to check for the compliance of the aerial device or its components to the relevant clauses and subclauses of this document.

Visual inspection shall be carried out by a person with normal or corrected vision without additional magnification, under normal lighting conditions.

A dimensional inspection shall be carried out to check for the compliance of the aerial devices or its components to the dimensions identified in Figure 1 and recorded in 5.15.

6.3 Design check and functional testing

A design check shall be carried out to verify the compliance of the aerial device or its components to the relevant clauses and subclauses of this document.

A functional testing shall be carried out to verify for the compliance of the aerial device or its components to the relevant clauses and subclauses of this document.

6.4 Durability of markings

The durability of the different markings shall be verified by thoroughly cleaning the marking for at least 1 min with a piece of lint-free cloth dampened with water and then rubbing it vigorously for a further minimum of 1 min with a piece of lint-free cloth dampened with isopropanol ($\text{CH}_3\text{-CH(OH)-CH}_3$).

The test shall be considered as passed if the marking remains legible and the letters do not smear.

The surface of the device may change. No signs of loosening shall be present for labels.

Marking made by moulding or engraving need not be subjected to this test.

6.5 Dye penetration test of insulating foam-filled booms

Five test pieces, each 100 mm long, and cut from different foam filled boom (i.e. five different booms) shall be completely immersed in a container filled with aqueous dye solution. The dye shall be selected in accordance with occupational health and environmental requirements.

NOTE Comparative dye penetration tests have been carried out, using various dyes. These tests indicate that the choice of the dye does not affect significantly the characterization of booms. In practice however, eosine ($\text{C}_{20}\text{H}_6\text{Br}_4\text{Na}_2\text{O}_5$) proves to be particularly convenient. The concentration of the eosine is about 1 % to 2 % in distilled water.

The container with the immersed test pieces shall be placed in a vacuum chamber at a pressure of less than 6 500 Pa (about 50 Torr). After 1 h, the pressure shall be released and the test pieces shall be removed from the solution.

In order to avoid dye solution spreading from the test piece ends during cutting, the test pieces shall be dried for 24 h at a temperature about 35 °C before cutting them.

After drying, the test pieces shall be cut 10 mm from each end. The new test pieces thus obtained shall be split lengthways.

The test shall be considered as passed if there is no sign of solution dye penetration in either the foam, at the junction of the foam and the structure, or in the structure.

6.6 Electrical tests

6.6.1 General

Unless otherwise stated, the test voltage shall be an alternating voltage generally having a frequency in the range 45 Hz to 65 Hz, normally referred to as power-frequency test voltage.

Unless otherwise stated, tests shall be carried out using an AC power source at power frequency in accordance with the requirements given in IEC 60060-1.

Measuring systems shall comply with IEC 60060-2 unless otherwise specified.

6.6.2 Electrical tests for insulating booms, insulating fixed handling tools and optical fibre cables

6.6.2.1 General

These tests are carried out in order to verify the ability of the insulating booms, insulating *fixed handling tools* and optical fibre cables to withstand electrical stress

- before and after exposure to humidity or water soaking,
- after infliction of a gash (only applies to optical fibre cables installed outside the boom and crossing the insulation gap).

In order to accommodate different production processes, this document includes two test methods, hereinafter referred to as Method A and Method B. Conformance with either of these test methods is required to comply with this document.

A change in raw material (fibreglass, resin, curing agent, etc.) or a change in process that will affect the resin wet-out of the fibreglass shall be considered new designs.

NOTE Different cross sectional dimensions do not warrant a new type test unless the boom shows a significant difference in fibre/resin ratio (greater than 10 % by mass) or fibre wet-out (as determined through visual inspection or through a dye-penetration test).

6.6.2.2 Method A – AC dielectric tests on test pieces cut from an insulating boom

6.6.2.2.1 General test conditions

Before electrical testing, each test piece shall be prepared by cleaning with isopropanol ($\text{CH}_3\text{-CH(OH)-CH}_3$) or in accordance with the *manufacturer's* instructions for use and then dried in air for 15 min.

These tests shall be carried out on three test pieces, each 300 mm long, which are cut from the boom in such a way as to avoid the use of material within 100 mm of an end. The ends of these test pieces shall be covered with conductive adhesive tape before each electrical test. At the time of conditioning in a humid atmosphere, this conductive tape shall be removed.

Conditioning in a humid atmosphere is carried out in accordance with IEC 60212.

The test location shall be at the standard atmospheric conditions given in Table 1 of IEC 60212:2010, i.e. with a temperature range from 18 °C to 28 °C.

6.6.2.2.2 Measurements

The test arrangement is shown in Figures 6 to 9. The measuring equipment shall be at least 2 m from the high voltage (HV) electrode. The measuring leads, shunt and optional protective gap shall be shielded and earthed. The test piece shall be mounted approximately 1 m above the ground on an insulating support. The guard electrode, on the earth (ground) side, is directly connected to earth.

A voltage of 100 kV r.m.s. at power frequency shall be applied between the electrodes and the current passing through the test piece shall be measured. The voltage should be increased from zero at a rate of 5 kV/s.

The specified acceptable current values are given in r.m.s. values. The maximum current recorded during the test is called I .

The phase difference between current and voltage shall be measured as follows:

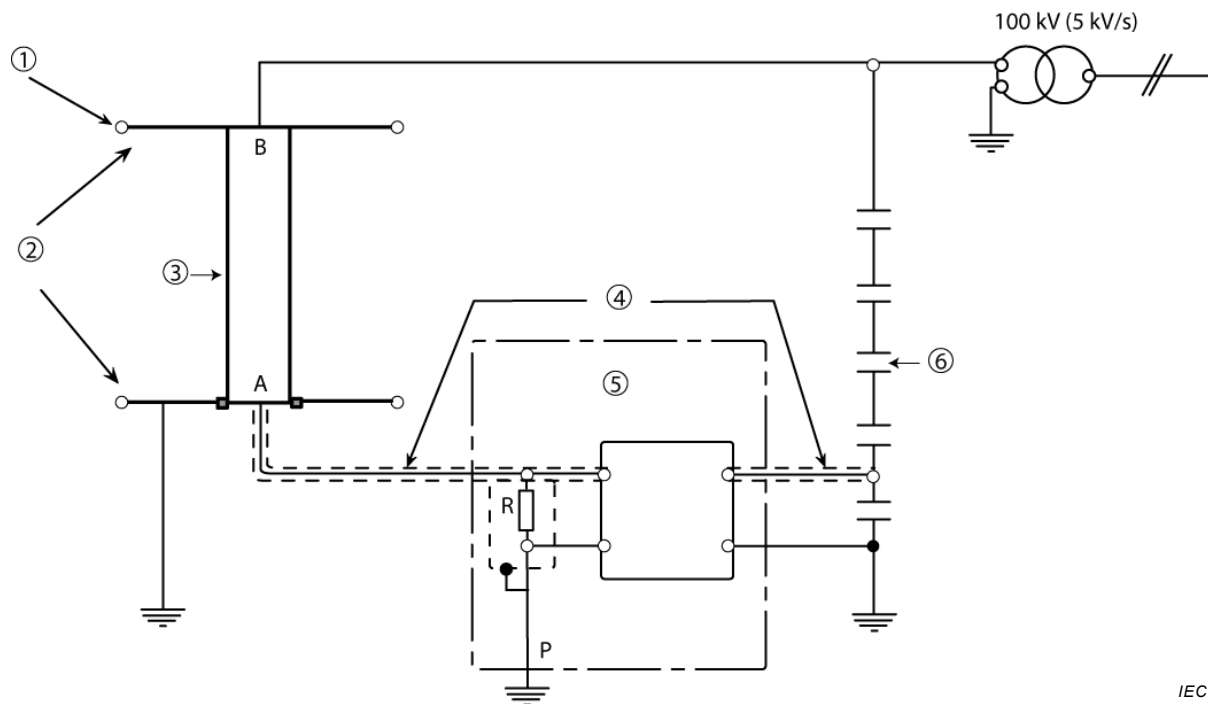
- current (earth end) by passing it through a known impedance (lower than 10 000 Ω);
- voltage (line end) by means of an appropriate divider.

The minimum phase angle recorded during the test is called φ .

During the tests there shall be no sign of flashover or puncture of any of the test pieces.

Before installing the test piece in the test set-up, first blank reference measurements with no test piece present shall be taken and the current and phase angle values shall be recorded.

NOTE This blank test will help verify the quality of the test set-up. The limits to be specified for the current and phase angle values are under consideration and will be included at the next maintenance cycle of the publication.



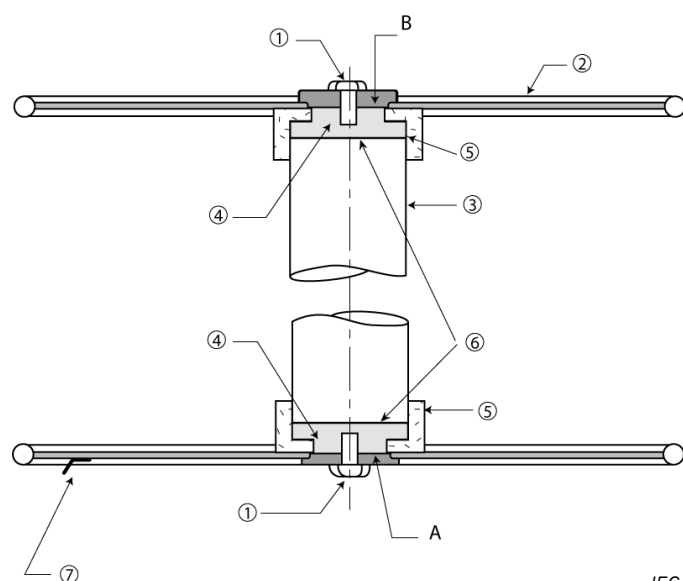
IEC

Key

- | | | | |
|------|--|---|-----------------------------------|
| 1 | continuous welded tube | 4 | screened leads |
| 2 | guard electrodes | 5 | measuring equipment |
| 3 | test piece | 6 | capacitive (or resistive) divider |
| R | resistance between points A and P $\leq 10\,000\ \Omega$ | P | connection to ground |
| A, B | electrode caps (See Figure 7) | | |

NOTE The measurement zone is situated at least 2 m away from any HV source

Figure 6 – AC dielectric test before and after exposure to humidity (method A) – Typical test arrangement



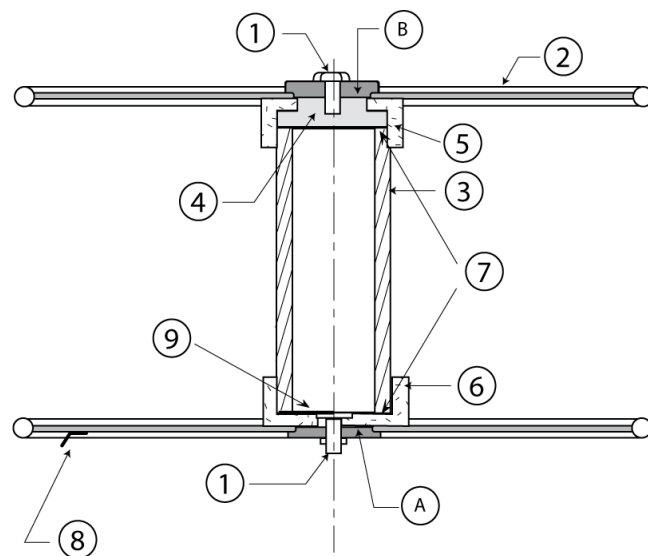
IEC

Key

- | | | | |
|---|-----------------------------------|---|---|
| A | insulating material electrode cap | B | brass electrode cap |
| 1 | socket for Ø 4 mm banana plug | 5 | insulating support |
| 2 | guard electrode | 6 | contact maintained by conductive adhesive tape |
| 3 | test piece of 300 mm length | 7 | socket for Ø 4 mm banana plug soldered on guard electrode |
| 4 | brass electrode | | |

NOTE Banana plugs can be replaced by other suitable electrical connectors.

Figure 7a – Dielectric tests of test piece of foam-filled boom or optical fibre cable



IEC

Key

- | | | | |
|---|--------------------------------------|---|--|
| A | insulating material electrode cap | B | brass electrode cap |
| 1 | socket for Ø 4 mm banana plug | 6 | insulating support E (see Figure 9c) |
| 2 | guard electrode | 7 | contact with boom section maintained by conducting adhesive tape |
| 3 | test piece of 300 mm length | 8 | socket for Ø 4 mm banana plug soldered on guard electrode |
| 4 | brass electrode | 9 | conducting adhesive tape ~ 5 mm width |
| 5 | insulating support D (see Figure 9b) | | |

Figure 7b – Dielectric tests of test piece of hollow boom

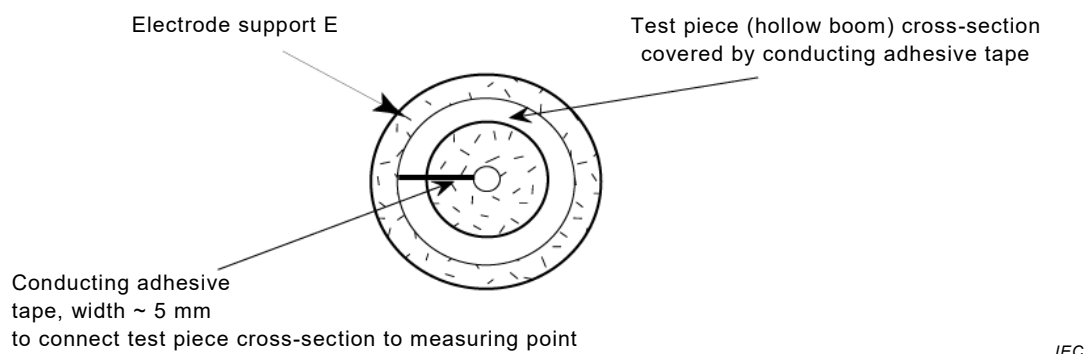
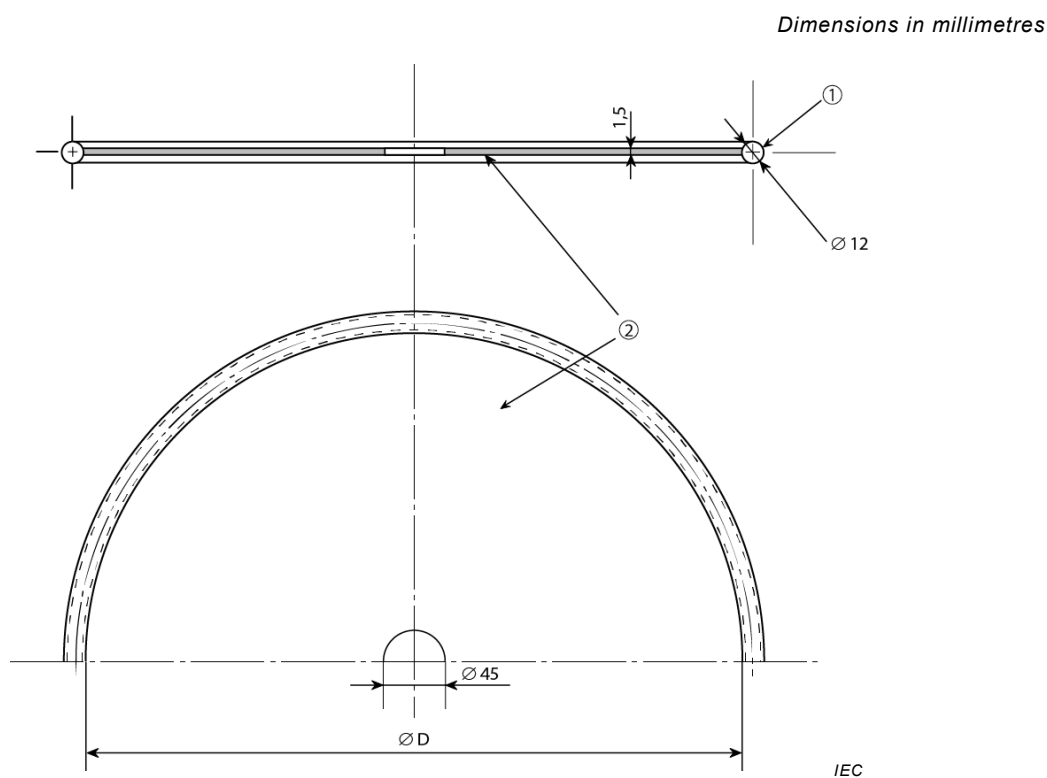


Figure 7c – Disposition of the conductive adhesive tape for leakage current measurement

Figure 7 – AC dielectric tests before and after exposure to humidity (method A) – Assembly diagram of the test piece to the guard electrodes

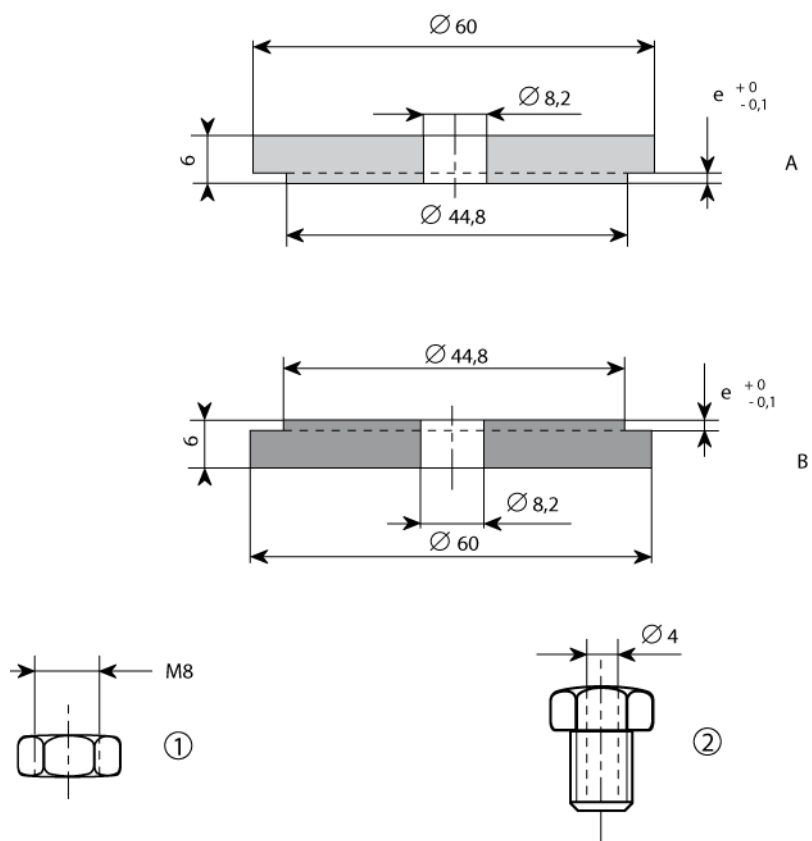


Key

- 1 Ø 12 mm copper tube soldered onto brass plate
- 2 brass thickness 1,5 mm
- Ø D > 2,5 times the diameter of the test piece

Figure 8a – Constructional drawing for guard electrodes (two required)

Dimensions in millimetres



IEC

Key

- A insulating material electrode cap
- B brass electrode cap
- 1 two M8 brass nuts for rods
- 2 two M8 × 10 brass screws with Ø 4 mm holes for tubes

Figure 8b – Constructional drawings for parts A and B**Figure 8 – AC dielectric tests before and after exposure to humidity (method A) – Constructional drawings for guard electrodes and parts**

Dimensions in millimetres

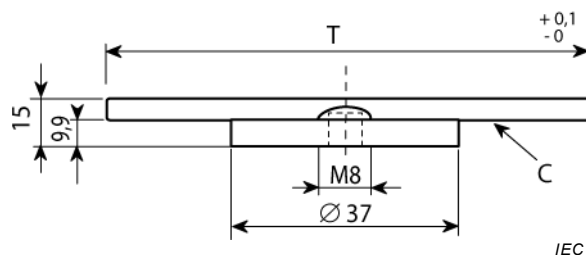


Figure 9a – Constructional drawing for brass electrode C

Dimensions in millimetres

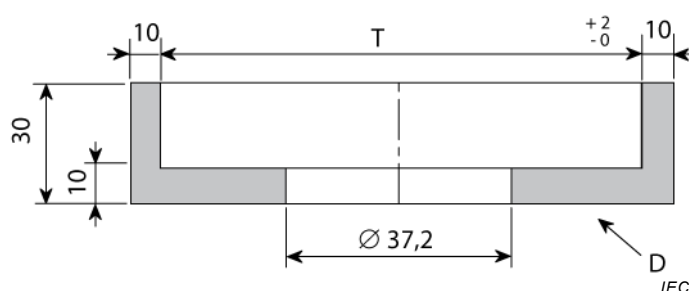


Figure 9b – Constructional drawing for insulating support D

Dimensions in millimetres

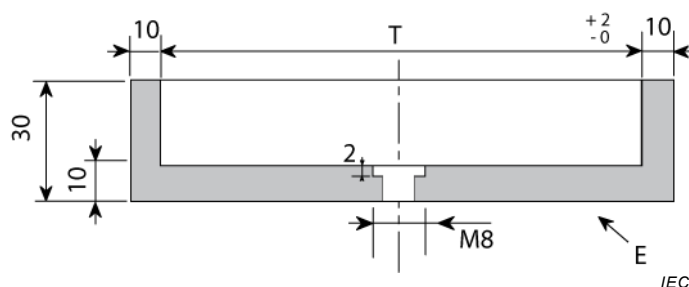


Figure 9c – Constructional drawing for insulating support E

Key

- C brass electrode
- D insulating support
- E insulating support
- T external dimension of test piece

Figure 9 – AC dielectric tests before and after exposure to humidity (method A) – Constructional drawings for brass electrode and for insulating support parts according to test piece

6.6.2.2.3 Tests before and after exposure to humidity

6.6.2.2.3.1 Test before exposure to humidity

After at least 24 h in the ambient atmosphere of the test area, the current I_1 is measured at an AC voltage of 100 kV r.m.s. at power frequency applied between the electrodes for 1 min.

The maximum AC current and the phase angle φ_1 between current and voltage shall be recorded.

6.6.2.2.3.2 Test after exposure to humidity

The test pieces shall be placed in a chamber and subjected to the following conditioning: 168 h/23 °C ± 2 °C/93 ± 5 %, as specified in Table 1 of IEC 60212:2010.

At the end of this 168 h period, the test pieces shall remain in an atmosphere of 93 % relative humidity and shall be tested upon return to room temperature in the test area.

After the test pieces have been lightly wiped with a dry lint free cloth, the AC current I_2 and phase angle φ_2 are measured under the same conditions as the AC current I_1 and φ_1 .

The test piece shall be located in the same position in relation to earth; the high-potential end of the test piece shall be the same for both tests.

6.6.2.2.3.3 Test results

The current I_1 measured shall not exceed 5 nA/mm². The phase angle φ_1 shall be higher than 80°.

After exposure to humidity, the current I_2 shall be lower than twice I_1 and the phase angle φ_2 higher than 50°.

6.6.2.2.4 Dielectric wet test

6.6.2.2.4.1 General test conditions

Before the test, each test piece shall be prepared by cleaning with isopropanol (CH₃-CH(OH)-CH₃) and then dried in air at room temperature for a period of not less than 15 min.

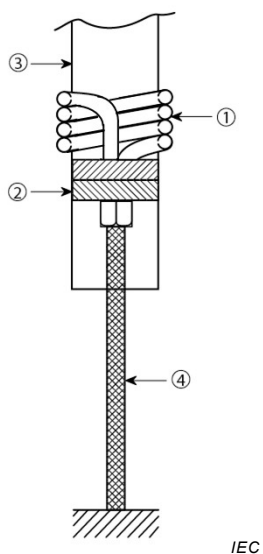
These tests are carried out on three test pieces, each 1,2 m long, which are cut from insulating booms and optical fibre cables; they shall not use material within 100 mm of the ends.

The electrodes shall be made of an aluminium or copper soft wire 3 mm to 4 mm in diameter, encircling the test piece with three or four turns, as shown in Figure 10.

The surface of the electrode should not be oxidized, and if a treatment against the oxidization is applied, it should not modify the characteristics of the water streaming on the test piece.

The test location shall be at the standard ambient conditions of IEC 60212, with a temperature range of 23 °C ± 5 °C.

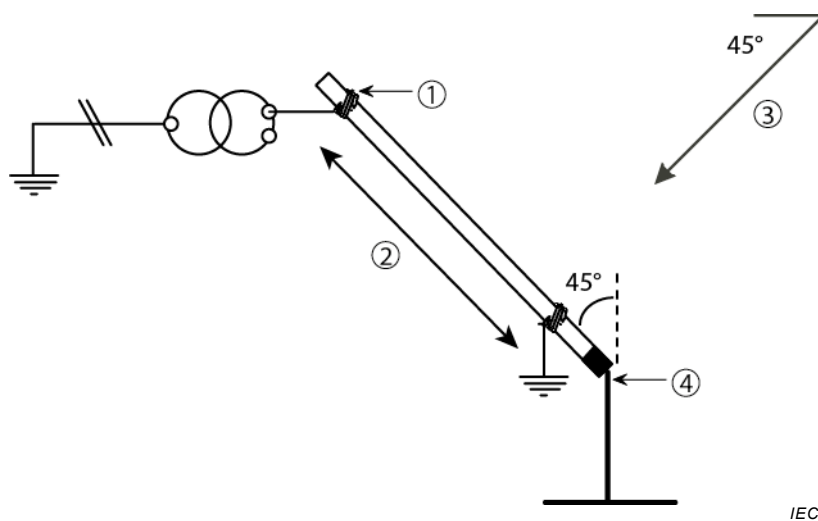
The test assembly shall comply with Figure 11.



Key

- 1 3 or 4 turns of aluminium or copper soft wire 3 mm to 4 mm in diameter
- 2 electrode fixed by adhesive tape
- 3 test piece
- 4 earthing lead

Figure 10 – Details of electrode arrangement



Key

- 1 high voltage electrode
- 2 electrode spacing, 1 m
- 3 rain direction
- 4 1 m minimum height fixing support

Figure 11 – Test arrangement

The test piece shall be inclined at an angle of 45° to the vertical. A voltage of 80 kV r.m.s. at power frequency shall be applied between the electrodes, in accordance with IEC 60060-1, for 1 h.

6.6.2.2.4.2 Wet conditions

The wet test shall be carried out in accordance with the standard wet test procedure described in IEC 60060-1 and corresponding to the following:

- average precipitation rate: 1,0 mm/min to 1,5 mm/min;
- water resistivity: $100 \Omega \cdot \text{m} \pm 15 \Omega \cdot \text{m}$.

However, contrary to the requirements of IEC 60060-1, the test piece shall not be pre-wetted before voltage application; spray and voltage shall be applied simultaneously for 1 h.

6.6.2.2.4.3 Test results

The test shall be considered as passed if there is:

- no *disruptive discharge*, i.e. flashover, sparkover or puncture;
- no tracking or erosion on the surface observed without a magnifying glass.

6.6.2.3 Method B – DC dielectric tests on test pieces cut from an insulating hollow boom

6.6.2.3.1 General test conditions

Before electrical testing, each test piece shall be prepared by cleaning with isopropanol ($\text{CH}_3\text{-CH}(\text{OH})\text{-CH}_3$) or in accordance with the *manufacturer's* instructions for use and then dried in air for 15 min.

These tests shall be carried out on three test pieces, each a maximum length of 900 mm, which are cut from the boom. The test arrangement is shown in Figure 12. The electrodes shall be installed on the inner and outer surface of the test specimen with a horizontal separation distance D of $300 \text{ mm} \pm 10 \text{ mm}$.

Electrodes shall be installed during the test only and not during conditioning.

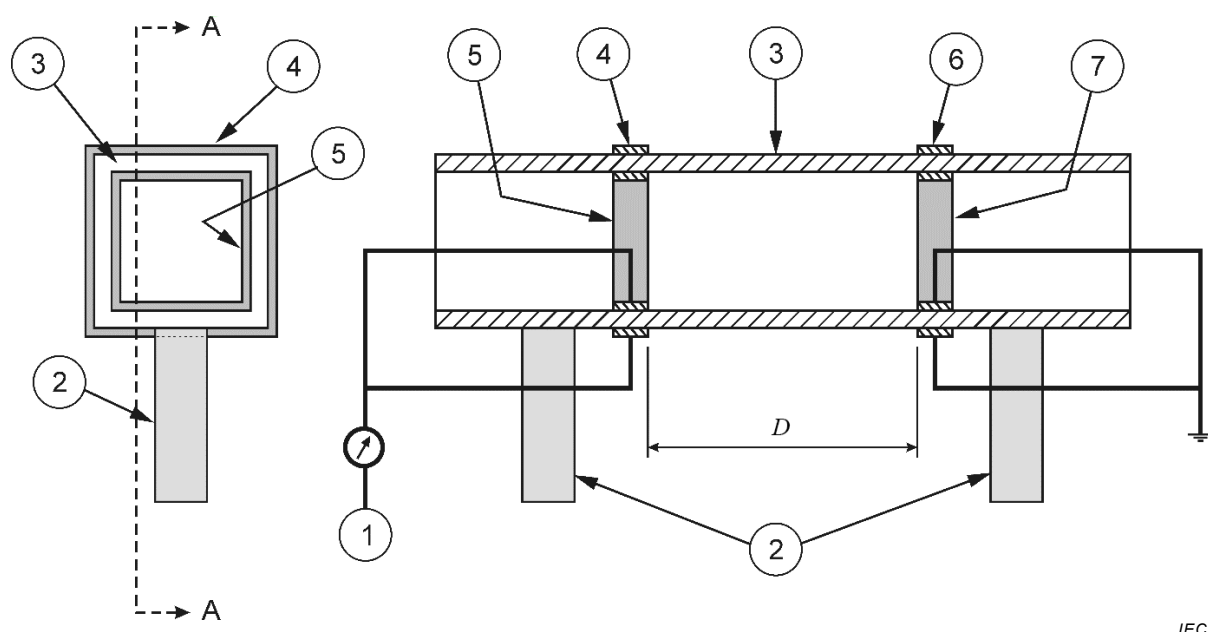
The test location shall be at the standard atmospheric conditions given in Table 1 of IEC 60212:2010, i.e. with a temperature range from 18 °C to 28 °C.

6.6.2.3.2 Measurements

A DC voltage of 100 kV shall be applied between the electrodes and the current passing through the test piece shall be measured. The maximum voltage rise shall be 3 kV/s.

The maximum direct current recorded during the test is called I .

Before installing the test piece in the test set-up, first blank reference measurements with no test piece present shall be taken.



Key

- | | |
|---------------------------------|--|
| 1 to DC voltage | 5 inner positive pole electrode |
| 2 insulating support | 6 outer negative pole electrode |
| 3 test piece of 900 mm length | 7 inner negative pole electrode |
| 4 outer positive pole electrode | <i>D</i> electrode separation distance |

Figure 12 – DC dielectric test before and after water soaking (method B) – Typical test arrangement

6.6.2.3.3 Test under dry and water soak conditions

6.6.2.3.3.1 Test under dry conditions

After at least 24 h in the ambient atmosphere of the test area, the current I_1 is measured at a DC voltage of 100 kV applied between the electrodes for 1 min.

The maximum DC current shall be recorded.

6.6.2.3.3.2 Test after water soaking

The test pieces shall be submersed in a tank filled with tap water for minimum period of 24 h.

After the test pieces have been lightly wiped with a dry lint free cloth and within 5 min of the end of soaking, the DC current I_2 shall be measured under the same conditions as the DC current I_1 .

The test piece shall be located in the same position in relation to earth; the high-potential end of the test piece shall be the same for both tests.

6.6.2.3.3.3 Test results

Under dry conditions and after water soaking, the DC current measured shall not exceed 100 μ A.