BS EN 60730-1:2016

BSI Standards Publication

Automatic electrical controls

Part 1: General requirements
(IEC 60730-1:2013, modified + COR1:2014)

bsi.

National foreword

This British Standard is the UK implementation of EN 60730-1:2016. It is derived from IEC 60730-1:2013, incorporating corrigendum September 2014 and amendment 1:2015. It supersedes BS EN 60730-1:2011 which will be withdrawn upon the publication of all revised editions of the following sub parts dependent on the 2011 edition:

BS EN 60730-2-2
BS EN 60730-2-3
BS EN 60730-2-4
BS EN 60730-2-5
BS EN 60730-2-6
BS EN 60730-2-7
BS EN 60730-2-8
BS EN 60730-2-9
BS EN 60730-2-10
BS EN 60730-2-11
BS EN 60730-2-12
BS EN 60730-2-13
BS EN 60730-2-14
BS EN 60730-2-15
BS EN 60730-2-19

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by tags (e.g. [C> <C]).

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1> <A1].

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Tags altered by IEC corrigendum September 2014 is indicated in the text by [AC1> <AC1].

The UK participation in its preparation was entrusted to Technical Committee CPL/72, Electrical control devices for household equipment and appliances.

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

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

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Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

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English Version

Automatic electrical controls - Part 1: General requirements (IEC 60730-1:2013 , modified + COR1:2014)

Dispositifs de commande électrique automatiques - Partie 1: Exigences générales (IEC 60730-1:2013 , modifiée + COR1:2014)

Automatische elektrische Regel- und Steuergeräte - Teil 1: Allgemeine Anforderungen (IEC 60730-1:2013 , modifiziert + COR1:2014)

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

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European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document (EN 60730-1:2016*)* consists of the text of IEC 60730-1:2013 + corrigendum 1:2014 prepared by IEC/TC 72 "Automatic electrical controls", together with the common modifications prepared by CLC/TC 72 "Automatic controls for household use*"*.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017-01-29
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	- *

** Justification for no dow:*
This European Standard supersedes EN 60730-1:2011. However, EN 60730-1:2011 remains valid until all the Part 2's which are used in conjunction with it have been withdrawn. No date of withdrawal (dow) has been given pending the updating of all the Part 2's to align with this EN 60730-1:2016. The applicable date of withdrawal is given in each Part 2. It is intended the dow for this Part 1 will be fixed once all the Part 2's have been updated.

This document supersedes EN 60730-1:2011.

EN 60730-1:2016 includes the following significant technical changes with respect to EN 60730-1:2011:

– changes of the title of the Standard into "*Automatic electrical controls – Part 1: General requirements*";
– revisions to Clause H.26 based on changes in technology, applications, and to improve consistency and layout;
– modification to Table H.12 to align with CISPR 22;
– revisions to Annex J to correlate the fault modes of thermistors, and to exempt thermistors used in conjunction with type 1 controls in SELV low power circuits from the tests specified in Annex J;
– new requirements covering battery-powered controls, and the use of batteries in controls;
– revision addressing the relay faults in Table H.24;
– new/updated requirements in Clause 24, for switch mode power supplies;
– revisions covering the allowance of screwless-type clamping units complying with IEC 60999-1;
– new requirements addressing remotely actuated control functions;
– addition of a new/updated leakage current diagram to align the Annex E diagram with the diagram in IEC 60990;
– updated requirements for temperature sensing controls.

This Part 1 is to be used in conjunction with the appropriate Part 2 for a particular type of control, or for controls for particular applications. This Part 1 may also be applied, so far as reasonable, to controls not mentioned in a Part 2, and to controls designed on new principles, in which case additional requirements may be considered to be necessary.

Where, for a particular clause or subclause, the text of Part 2 indicates:

Addition: the Part 1 text applies with the additional requirement indicated in a Part 2;

Modification: the Part 1 text applies with a minor change as indicated in a Part 2;

Replacement: the Part 2 text contains a change which replaces the Part 1 text in its entirety.

Where no change is necessary, the Part 2 indicates that the relevant clause or subclause applies.

NOTE In this standard the following print types are used:

– Requirements proper: in roman type.

– *Test specifications: in italic type.*

– Explanatory matter: in smaller roman type.

- Defined terms: **bold type**.

Some table titles contain reference in brackets to table numbers in IEC 60730-1:1999 (edition 3) for ease of correlation between Parts 2 and the Part 1.

Clauses, subclauses, notes, tables, figures and annexes which are additional to those in IEC 60730-1:2013 are prefixed “Z”.

Special national conditions are listed in Annex ZB (normative) which forms part of this standard.

National deviations are listed in Annex ZC (informative).

Endorsement notice

The text of the International Standard IEC 60730-1:2013 was approved by CENELEC as a European Standard with agreed common modifications.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
-	-	Electric cables - Low voltage energy cables of rated voltages up to and including 450/750 V (U_o/U) Part 2-11: Cables for general applications - Flexible cables with thermoplastic PVC insulation	EN 50525-2-11	-
-	-	Electric cables - Low voltage energy cables of rated voltages up to and including 450/750 V (U_o/U) Part 2-21: Cables for general applications - Flexible cables with crosslinked elastomeric insulation	EN 50525-2-21	-
IEC 60038	-	IEC standard voltages	EN 60038	-
IEC 60065 (mod) + A1 (mod) - - + A2 (mod) -	2001 2005 - - 2010 -	Audio, video and similar electronic apparatus - Safety requirements	EN 60065 + A1 + corrig. August + A11 + A2 + A12	2002 [1)] 2006 [1)] 2007 [1)] 2008 [1)] 2010 [1)] 2011 [1)]
IEC 60068-2-75	-	Environmental testing Part 2-75: Tests - Test Eh: Hammer tests	EN 60068-2-75	-
IEC 60085	-	Electrical insulation - Thermal evaluation and designation	EN 60085	-
IEC 60099-1	-	Surge arresters Part 1: Non-linear resistor type gapped surge arresters for a.c. systems	EN 60099-1	-
IEC 60112 + A1	2003 2009	Method for the determination of the proof and the comparative tracking indices of solid insulating materials	EN 60112 + A1	2003 2009

[1)] Superseded by EN 60065:2014 (IEC 60065:2014): DOW = 2017-11-17.

Publication	Year	Title	EN/HD	Year
IEC 60127-1	-	Miniature fuses Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links	EN 60127-1	-
IEC 60227-1	-	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V Part 1: General requirements	-	-
IEC 60245-1	-	Rubber insulated cables - Rated voltages up to and including 450/750 V Part 1: General requirements	-	-
IEC 60269-1	-	Low-voltage fuses Part 1: General requirements	EN 60269-1	-
IEC 60335-1 (mod) -	2010 -	Household and similar electrical appliances - Safety Part 1: General requirements	EN 60335-1 + AC	2012 2014
IEC 60364	Series	Low-voltage electrical installations	HD 384 / HD 60364	Series
IEC 60384-14	-	Fixed capacitors for use in electronic equipment Part 14: Sectional specification - Fixed capacitors for electromagnetic interference suppression and connection to the supply mains	EN 60384-14	-
IEC 60384-16	-	Fixed capacitors for use in electronic equipment Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors	EN 60384-16	-
IEC 60384-17	-	Fixed capacitors for use in electronic equipment Part 17: Sectional specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors	EN 60384-17	-
IEC 60417	series	Graphical symbols for use on equipment	-	-
IEC 60423	-	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for conduits and fittings	EN 60423	-
IEC 60529 - + A1	1989 - 1999	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corrig. May + A1	1991 1993 2000
IEC 60539	series	Directly heated negative temperature coefficient thermistors	EN 60539	series
IEC 60664-1	2007	Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests	EN 60664-1	2007
IEC 60664-3 + A1	2003 2010	Insulation coordination for equipment within low-voltage systems Part 3: Use of coating, potting or moulding for protection against pollution	EN 60664-3 + A1	2003 2010

Publication	Year	Title	EN/HD	Year
IEC 60664-4	-	Insulation coordination for equipment within low-voltage systems Part 4: Consideration of high-frequency voltage stress	EN 60664-4	-
IEC 60669-1 (mod) + A1 (mod) + A2 (mod)	1998 1999 2006	Switches for household and similar fixed-electrical installations Part 1: General requirements	EN 60669-1 + A1 + A2	1999 2002 2008
IEC 60695-2-10	-	Fire hazard testing Part 2-10: Glowing/hot-wire based test methods - Glow-wire apparatus and common test procedure	EN 60695-2-10	-
IEC 60695-2-11	2000	Fire hazard testing Part 2-11: Glowing/hot-wire based test methods - Glow-wire flammability test method for end-products	EN 60695-2-11	2001 [2)]
IEC 60695-10-2	-	Fire hazard testing Part 10-2: Abnormal heat - Ball pressure test	EN 60695-10-2	-
IEC 60730	series	Automatic electrical controls for household and similar use	EN 60730	series
IEC 60738-1	-	Thermistors - Directly heated positive temperature coefficient Part 1: Generic specification	EN 60738-1	-
IEC 60738-1-1	-	Thermistors - Directly heated positive step-function temperature coefficient Part 1-1: Blank detail specification - Current limiting application - Assessment level EZ	EN 60738-1-1	-
IEC 60947-1	2007	Low-voltage switchgear and controlgear Part 1: General rules	EN 60947-1	2007
IEC 60998-2-2	-	Connecting devices for low-voltage circuits for household and similar purposes Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units	EN 60998-2-2	-
IEC 60998-2-3	-	Connecting devices for low-voltage circuits for household and similar purposes Part 2-3: Particular requirements for connecting devices as separate entities with insulation-piercing clamping units	EN 60998-2-3	-
IEC 60999-1	-	Connecting devices - Electrical copper conductors - Safety requirements for screw-type and screwless-type clamping units Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)	EN 60999-1	-
IEC 61000	Series	Electromagnetic compatibility (EMC)	EN 61000	Series

[2)] Superseded by EN 60695-2-11:2014 (IEC 60695-2-11:2014): DOW = 2017-03-13.

Publication	Year	Title	EN/HD	Year
IEC 61000-3-2	-	Electromagnetic compatibility (EMC) Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)	EN 61000-3-2	-
IEC 61000-3-3	2008	Electromagnetic compatibility (EMC) Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection	EN 61000-3-3	2008 [3)]
IEC 61000-4-2	2008	Electromagnetic compatibility (EMC) Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009
IEC 61000-4-3	-	Electromagnetic compatibility (EMC) Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	-
IEC 61000-4-4	-	Electromagnetic compatibility (EMC) Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	-
IEC 61000-4-5	-	Electromagnetic compatibility (EMC) Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	-
IEC 61000-4-6	-	Electromagnetic compatibility (EMC) Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	-
IEC 61000-4-8	-	Electromagnetic compatibility (EMC) Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	EN 61000-4-8	-
IEC 61000-4-11	-	Electromagnetic compatibility (EMC) Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	EN 61000-4-11	-
IEC 61000-4-13 + A1	2002 2009	Electromagnetic compatibility (EMC) Part 4-13: Testing and measurement techniques - Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests	EN 61000-4-13 + A1	2002 2009

[3)] Superseded by EN 61000-3-3:2013 (IEC 61000-3-3:2013): DOW = 2016-06-18.

Publication	Year	Title	EN/HD	Year
IEC 61000-4-28	-	Electromagnetic compatibility (EMC) Part 4-28: Testing and measurement techniques - Variation of power frequency, immunity test for equipment with input current not exceeding 16 A per phase	EN 61000-4-28	-
IEC 61058-1	-	Switches for appliances Part 1: General requirements	-	-
IEC 61210	-	Connecting devices - Flat quick-connect terminations for electrical copper conductors - Safety requirements	EN 61210	-
IEC 61249	series	Materials for printed boards and other interconnecting structures	EN 61249	series
IEC 61558-2-6	-	Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers	EN 61558-2-6	-
IEC 61558-2-16	-	Safety of transformers, reactors, power supply units and similar products for voltages up to 1 100 V Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units	EN 61558-2-16	-
IEC 61643-11	-	Low-voltage surge protective devices Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods	EN 61643-11	-
IEC 62326	series	Printed boards	EN 62326	series
CISPR 11	-	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	EN 55011	-
CISPR 14-1 + A1	2005 2008	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus Part 1: Emission	EN 55014-1 + A1	2006 2009
CISPR 16-1-1	-	Specification for radio disturbance and immunity measuring apparatus and methods Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus	EN 55016-1-1	-
CISPR 22 (mod)	2008	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement	EN 55022 + AC	2010 2011
ISO 16484-2	-	Building automation and control systems (BACS) Part 2: Hardware	EN ISO 16484-2	-

Annex ZB
(normative)

Special national conditions

Special national condition: National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions.

NOTE If it affects harmonization, it forms part of the European Standard.

For the countries in which the relevant special national conditions apply these provisions are normative, for other countries they are informative.

Clause	Special national condition
2.7.2	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 0 controls are not allowed.
2.7.3	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 01 controls are not allowed.
2.7.5.3	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 01 controls are not allowed.
4.3.3.1	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 0 and Class 01 controls are not allowed.
4.3.3.3	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 0 and Class 01 controls are not allowed.
6.8.2.1	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 0 controls are not allowed.
6.8.2.2	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 01 controls are not allowed.
6.8.3.1	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 0 controls are not allowed.
6.8.3.2	**Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom** Class 01 controls are not allowed.

7.4.3 **United Kingdom**

Add to the requirement:

Terminals intended exclusively for a live external conductor shall be indicated by the letter ‘L’.

7.4.3.2 **United Kingdom**

Add to the requirement:

The letter ‘L’ shall not be used except as indicated above.

9.1.1 **Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom**

Class 01 controls are not allowed.

9.1.2 **Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom**

Class 01 controls are not allowed.

11.9.4 **Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom**

Class 01 controls are not allowed.

Table 12 **Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom**

Table footnote [d] Class 01 controls are not allowed.

16.2.1 **Finland, Norway and Sweden**

In the first dashed paragraph, replace "*(-10 ± 2) °C*" by "*(-25 ± 2) °C*".

Annex ZC
(informative)

A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN-CENELEC national member.

This European Standard falls under Directives LVD (2006/95/EC), RTTED (1999/5/EC) and EMC (2004/108/EC).

NOTE (from CEN/CENELEC IR Part 2:2011, 2.17) Where standards fall under EU Directives, it is the view of the Commission of the European Communities (OJ No C 59, 1982-03-09) that the effect of the decision of the Court of Justice in case 815/79 Cremonini/Vrankovich (European Court Reports 1980, p. 3583) is that compliance with A-deviations is no longer mandatory and that the free movement of products complying with such a standard should not be restricted except under the safeguard procedure provided for in the relevant Directive.

A-deviations in an EFTA-country are valid instead of the relevant provisions of the European Standard in that country until they have been removed.

Clause	Deviation
11.1.2	**Sweden** (Ordinance 1991:1290) Mercury is not allowed in switches and controls, such as level switches, thermostats and relays.
11.1.3	**United Kingdom** (Statutory Instrument 1768:1994) Add to the requirement: These regulations apply to all plugs for domestic use at a voltage of not less than 200 V and in general allow only plugs to BS 1363 to be fitted.

Annex ZD
(normative)

EMC immunity for controls

ZD.1 Electromagnetic compatibility (EMC) requirements – Immunity

The tests of Annex ZD apply to **operating controls** of **Type 1 action** intended to be used as "**free standing controls, independently mounted and/or in-line cord controls**" for EMC immunity instead of Clause H.26. See Figure ZD.1.

Annex ZD may be made applicable to incorporated and/or integrated controls if so requested by their manufacturer.

NOTE For EMC emission, Clause H.23 applies.

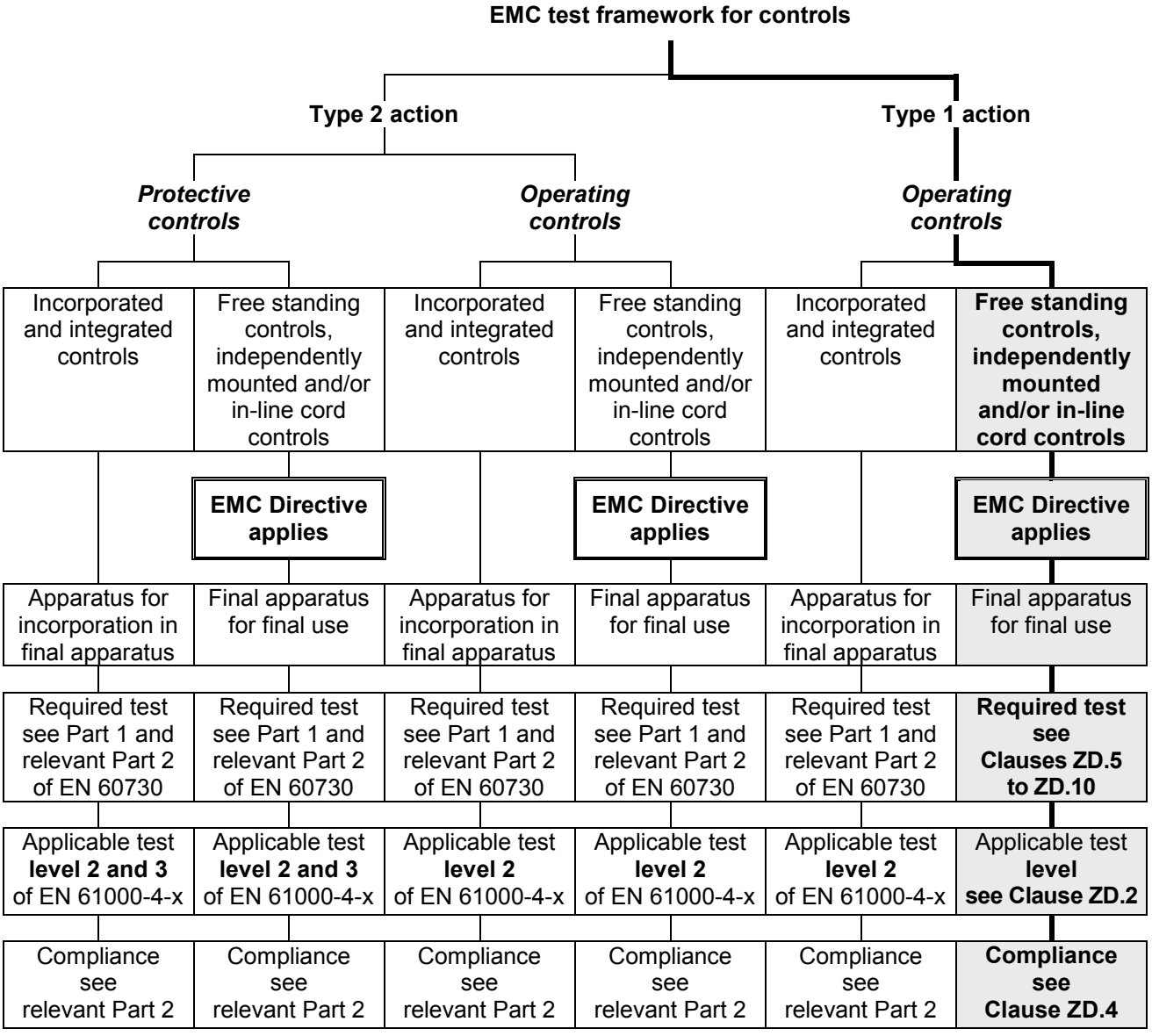

Figure ZD.1 – EMC test framework for controls

ZD.2 Classification of the control

Table ZD.1 – Classification and test overview

Control declaration	Installation and environmental condition									
	ESD		**Radiated EMF field**			**Burst**	**Surge**	**Conducted disturbance**	**Power magnetic field**	**Voltage dips & interruption**
	Environmental class EN 61000 -4-2		Environmental class EN 61000 -4-3 [d]			Environment class EN 61000 -4-4	Installation class [c] EN 61000 -4-5	Environment class EN 61000 -4-6	Environment class EN 61000 -4-8	Environment class EN 61000 -4-11
EMC level	Level 2	Level 3	Level 2	Level 2	Level 1	Level 2	Class 2	Level 2	Level 2	Class 2
Residential [a]	Contact dis-charge	Air dis-charge	< 1,0 GHz	1,4 GHz … 2,0 GHz	2,0 GHz … 2,7 GHz	Protected	Power and signal cables are well separated		Well protected	
EMC level	Level 2	Level 3	Level 3	Level 2	Level 1	Level 3	Class 3	Level 3	Level 4	Class 3
Industrial [b]	Contact dis-charge	Air dis-charge	< 1,0 GHz	1,4 GHz … 2,0 GHz	2,0 GHz … 2,7 GHz	Typical industrial	Power and signal cables run in parallel		Typical industrial	

[a] Residential: Controls are restricted for the use only in residential, commercial and light industrial environment (EN 61000-6-1).

[b] Industrial: In addition to residential, controls are also suitable for industrial environment (EN 61000-6-2).

[c] Installation classes: see Annex R.

[d] EN 61000-4-20 may be used for small EUT's as defined in EN 61000-4-20:2010, 6.1.

ZD.3 Information

Additional items to Table 1 (7.2 of the previous edition):

	Information	Clause or subclause	Method
Z3	According to the electromagnetic environment of one of the two EMC levels	ZD.2	X
Z4	EUT to be tested without primary protection, Table ZD.3, footnote [a]	ZD.5	X
Z5	Cable length up to or equal to 30 m, Table ZD.3, footnote [b]	ZD.5	X
Z6	Data line length < 10 m, Table ZD.3, footnote [c]	ZD.5	X
Z7	Test level (= protection level when upstream protection is not in place), Table ZD.3, footnote [d]	ZD.5	X
Z8	Data line length up to and including 3 m, Table ZD.5	ZD.5	X
Z9	Applicable of test and frequency, Table ZD.9	ZD.9	X

ZD.4 Evaluation of compliance

The compliance criteria are given in Table ZD.2 and are based on the operating conditions and the functional specification of the control during and after the test.

Number of test samples: minimum one sample

After the test, the control shall meet the requirements of Clause 8, 17.5 and Clause 20. If, as a result of the application of the tests defined in Annex ZD, the control becomes dangerous or unsafe, the control shall be deemed to have failed the test.

Table ZD.2 – Compliance criteria

Operating conditions	Compliance criteria		
	A	B	C
Digital inputs/outputs	No deviation on input readings No deviation on output settings (no change of state)	No deviation on input readings No deviation on output settings (no change of state)	Any error, such as a change of state, destruction of data, and loss of a connection is permitted, provided the initial state is restored automatically after the test - Automatic recovery after the test [b]
Analogue inputs/outputs	Deviation as declared in the final product specification is permitted [a].	Deviation is permitted during test.	
Display, Monitor	Operation shall be possible at reasonable comfort.	Deviation is permitted (e.g. display fault, such as flickering)	
Local operator override / switching	No deviation	Deviation is permitted for analogue values. No change of state for digital values	
Communication ports	No deviation detectable by the user The reduced data transfer rate shall be reasonable for the control operation.	Deviation is permitted. Loss of communication during the test Automatic recovery after the test	

[a] The permissible deviation is with respect to the value without electromagnetic interference. This means that any basic deviation is ignored.

[b] This compliance criterion is based on the fact that the control operation in the end user application will be unsupervised.

ZD.5 Surge immunity test

The control is mounted as specified in 4.1.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-5.

The severity levels for the declared installation class are specified in Table ZD.3.

Repetition rate: maximum 1/min

Polarity: positive (+) and negative (-)

Number of pulses: at least five pulses for each polarity are applied at selected points

Phase angle: 0°, 90°, 180° and 270° versus the phase angle of the AC line voltage to the equipment under test, with a tolerance of ± 10°

NOTE Most protectors in common use have low average power capabilities, even though their peak power or peak energy handling can deal with high currents. Therefore, the maximum repetition rate (the time between two surges and the recovery time) depends on the built-in protection devices of the EUT.

Table ZD.3 – Test levels for voltage surges

	Test levels kV											
Control declaration	**AC power supply and AC I/O directly connected to mains network**		**AC power supply and AC I/O not directly connected to mains network**		**DC power supply and DC I/O directly connected thereto**		**Unsymmetrical operated circuits/lines [c]**		**Symmetrical operated circuits/lines [c]**		**Shielded I/O and shielded communication lines**	
	Coupling mode		Coupling mode		Coupling mode		Coupling mode		Coupling mode		Coupling mode	
EMC Level	line to line	line to earth	line to line	line to earth	line to line	line to earth	line to line	line to earth	line to line	line to earth	line to line	line to earth
Residential	1	2,0	NA	NA	NA	NA	0,5	1,0	NA	1,0	NA	0,5
Industrial	1,0	2,0	1,0 [d]	2,0 [a,d]	0,5 [e]	0,5 [e]	1,0 [b]	2,0 [a,b]	NA	2,0 [a,b]	NA	2,0 [b]

[a] Normally tested with primary protection unless declared otherwise by the manufacturer (Clause ZD.3, requirement Z4).

[b] The test level shall be lowered to the next lower one if the cable length is shorter than or equal to 30 m (Clause ZD.3, requirement Z5).

[c] This test is not applicable to interconnection cables used as data lines and a length of up to 10 m (Clause ZD.3, requirement Z6).

[d] If protection is specified upstream from the EUT, the test level should correspond to the protection level when the protection is not in place (Clause ZD.3, requirement Z7).

[E] Not applicable to input ports intended for connection to a battery or a rechargeable battery that must be removed or disconnected from the apparatus for recharging. Apparatus with a DC power input port intended for use with an AC–DC power adaptor shall be tested on the AC power input of the AC–DC power adaptor specified by the manufacturer or, where none is so specified, using a typical AC–DC power adaptor. DC ports, which are not intended to be connected to a DC distribution network are treated as signal ports.

Compliance criteria: B (see Table ZD.2)

ZD.6 Electrical fast transient/burst immunity test

The control is mounted as specified in 4.1.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-4.

The severity levels for the declared EMC level are specified in Table ZD.4.

Polarity: positive (+) and negative (-)

Duration: one minute for each polarity

Table ZD.4 – Test levels for burst

Control declaration	Open circuit output test voltage and repetition rate of the impulses			
EMC level	On power port, PE		On I/O (input/output) signal, data and control ports	
	Voltage peak kV	Repetition rate kHz	Voltage peak kV	Repetition rate kHz
Residential	1	5	0,5	5
Industrial	2	5	1	5

Table ZD.5 – Test application for electrical fast transient burst test

AC power supply and control output for direct connection to the supply	DC power supply and control outputs for direct connection to the supply	Data lines [a]
Direct application via CDN according to EN 61000-4-4 between the reference ground plane and – each power supply line, individually – the nearest protective earth terminal – to all multiple combinations of power supply lines and also earth line	Capacitive clamp [b]	Capacitive clamp
[a] Applicable only to lines longer than 3 m, according to the manufacturer's declaration (Clause ZD.3, requirement Z8). [b] Not applicable to lines connected to dedicated non-rechargeable power supplies.		

Compliance criteria B: (see Table ZD.2)

ZD.7 Radio-frequency electromagnetic field immunity

ZD.7.1 Immunity to conducted disturbances

The control is mounted as specified in 4.1.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-6, the complete frequency range being swept at least once.

The severity levels for the declared EMC level are specified in Table ZD.6.

Table ZD.6 – Test levels for conducted disturbances on mains, I/O lines and DC power lines

Control declaration **EMC level**	**Frequency ranges: 150 kHz – 80 MHz**	
	Voltage level (EMF)	
	U_0 dBμV	U_0 V
Residential	130 [a c d]	3 [a c d]
Industrial	140 [a b c]	10 [a b c]

[a] The test level can also be defined as the equivalent current into a 150 Ω load.

[b] Except for the ITU broadcast frequency band 47 MHz to 68 MHz, where the level shall be 3 V.

[c] For I/O lines only applicable if the total cable length according to the manufacturer's functional specification may exceed 3 m.

[d] For input and output DC power port lines only applicable if the total cable length according to the manufacturer's functional specification may exceed 3 m.

Compliance criteria A: (see Table ZD.2)

ZD.7.2 Electrostatic discharge

The control is mounted as specified in 4.1.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-2.

The severity levels for the declared EMC level are specified in Table ZD.7.

Number of discharges for direct:	at least 5 discharges in each polarity (+/-)
Number of discharges for indirect horizontal: (Horizontal coupling plane)	at least 5 discharges in each polarity (+/-) for each position opposite the centre point of the horizontal coupling plane
Number of discharges for indirect vertical: (Vertical coupling plane)	at least 5 discharges in each polarity (+/-)

Table ZD.7 – Test levels for electrostatic discharge

Control declaration EMC level		Contact discharge Test voltage kV	Air discharge Test voltage kV
Residential and Industrial	Direct	4	8
	Indirect	4	Not applicable

Compliance criteria B: (see Table ZD.2)

ZD.8 Immunity to radiated electromagnetic fields

The control is mounted as specified in 4.1.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-3, the complete frequency range being swept at least once.

The severity levels for the declared EMC level are specified in Table ZD.8.

Table ZD.8 – Test levels for radiated electromagnetic field on enclosure

Control declaration EMC level	Frequency ranges		
	80 MHz to 1 GHz	1,4 GHz to 2 GHz	2,0 GHz to 2,7 GHz
	Field strength V/m	Field strength V/m	Field strength V/m
Residential	3	3 [a]	1 [a]
Industrial	10 [b]	3 [a]	1 [a]

[a] The frequency range has been selected to cover the frequencies with the highest potential risk of a disturbance.

[b] Except for the ITU broadcast frequency bands 87 MHz to 108 MHz, 174 MHz to 230 MHz, and 470 MHz to 790 MHz, where the level shall be 3 V/m.

Compliance criteria A: (see Table ZD.2)

ZD.9 Immunity to power-frequency magnetic fields

This test is only applicable to controls containing devices susceptible to magnetic fields. (e.g. hall-effect devices) and if declared by the manufacturer (Clause ZD.3, requirement Z9).

Such a control is supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with EN 61000-4-8.

The severity levels for the declared EMC level are specified in Table ZD.9.

Table ZD.9 – Test levels for power-frequency magnetic field on enclosure

Control declaration EMC level	Power A/m	Frequency Hz
Residential	3	50 / 60 [a]
Industrial	30	50 / 60 [a]
[a] The test shall be carried out at the frequencies appropriate to the power supply frequency. Equipment intended for use in areas supplied only at one of these frequencies need only be tested at that frequency (Clause ZD.3, requirement Z9).		

Compliance criteria A: (see Table ZD.2)

ZD.10 Test of the influence of voltage dips and voltage interruption in the power supply network

During the test, the control shall be initially operated at its rated voltage. The control is operated at representative operating conditions.

It is tested in accordance with EN 61000-4-11. The test is only applicable to AC power input ports. The test levels for the declared EMC level are specified in Tables ZD.10 and ZD.11.

Table ZD.10 – Voltage dips (50 Hz / 60 Hz)

Control declaration EMC level	Voltage ΔU reduction	Duration in periods 50 Hz/60 Hz	Compliance criteria (see Table ZD.2)
Residential and industrial	30 %	25/30	C
Industrial	60 %	10/12	C
NOTE Voltage shift at zero crossing.			

Table ZD.11 – Voltage interruption (50 Hz / 60 Hz)

Control declaration EMC level	Voltage ΔU reduction	Duration in periods	Compliance criteria (see Table ZD.2)
Residential	100 %	0,5	B
Residential and industrial	100 %	1	B
Residential and industrial	100 %	250/300	C

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

AUTOMATIC ELECTRICAL CONTROLS –

Part 1: General requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This Consolidated version of IEC 60730-1 bears the edition number 5.1. It consists of the fifth edition (2013-11) [documents 72/899/FDIS and 72/928/RVD] and its corrigendum 1 (september 2014), and its amendment 1 (2015-12) [documents 72/1017/FDIS and 72/1026/RVD]. The technical content is identical to the base edition and its amendment.

International Standard IEC 60730-1 has been prepared by IEC technical committee 72: Automatic electrical controls.

This edition constitutes a technical revision. The major changes with respect to the previous edition are as follows.

– modification of the title and scope;
– revisions to Clause H.26 based on changes in technology, applications, and to improve consistency and layout;
– modification to Table H.12 to align with CISPR 22;
– revisions to Annex J to correlate the fault modes of thermistors and to exempt thermistors used in conjunction with type 1 controls in SELV low power circuits from the tests specified in Annex J;
– new requirements covering battery-powered controls, and the use of batteries in controls;
– revision addressing the exclusion of relay faults;
– new/updated requirements in Clause 24, for switch mode power supplies;
– revisions covering the allowance of screwless-type clamping units complying with IEC 60999-1;
– new requirements addressing remotely actuated control functions;
– addition of a new/updated leakage current diagram to align the Annex E diagram with the diagram in IEC 60990;
– updated requirements for temperature sensing controls.

A list of all parts of the IEC 60730 series, under the general title: *Automatic electrical controls*, can be found on the IEC website.

In the development of a fully international standard to cover automatic controls for household and similar use, it has been necessary to take into consideration the differing requirements resulting from practical experience in various parts of the world and to recognize the variation in national electrical systems and wiring rules.

The “in some countries” notes regarding differing national practices are contained in the following subclauses:

2.1.5	11.11.1.2	17.10.4
2.7.2	11.11.1.3	17.12.5
2.7.3	11.11.1.4	18.1.6
2.14.2	12.1.6	18.1.6.1
4.2.1	12.3	18.1.6.2
6.6.1	Table 12 (13.2.1), footnote a	18.1.6.3
Table 1 (7.2), footnote d	13.3.4	18.4
7.4.3	14.4	19.2.4.1
7.4.3.2	Table 13 (14.7.4), footnote f	19.2.5.1
8.1.1.1	15.1	21.1
8.4	16.2.1	21.4
9.3.2	17.1.3.1	27.2.3.1
9.3.4	17.2.2	Annex C
9.5.2	17.2.3	Annex D
Table 3 (10.1.4), footnote b	17.2.3.1	H.26.10
10.1.4.1	Table 14 (17.2.5)	Table H.18 (H.26.10.4)
10.1.14	Table 15 (17.2.5)	H.27.1.1.3
10.1.16	Table 16 (17.2.5)	Table K.1, footnote b
10.1.16.1	17.5.1	Table K.2, footnote b

Table 6 (10.2.1), footnote b	17.7.7	T.3.2
11.5	17.8.4.1	
Table 10 (11.8.2), footnote b	17.10	

It is envisaged that in the next edition of this standard it will be found possible to remove those differences that are covered by new IEC standards now being prepared by other technical committees.

This part 1 is to be used in conjunction with the appropriate part 2 for a particular type of control, or for controls for particular applications. This part 1 may also be applied, so far as reasonable, to controls not mentioned in a part 2, and to controls designed on new principles, in which cases additional requirements may be considered to be necessary.

Where, for a particular clause or subclause, the text of part 2 indicates:

Addition: the part 1 text applies with the additional requirement indicated in a part 2;

Modification: the part 1 text applies with a minor change as indicated in a part 2;

Replacement: the part 2 text contains a change which replaces the part 1 text in its entirety.

Where no change is necessary, the part 2 indicates that the relevant clause or subclause applies.

NOTE In this standard the following print types are used:

– Requirements proper: in roman type;

– *Test specifications: in italic type;*

– Explanatory matter: in smaller roman type;

– Defined terms: **bold type**.

Some table titles contain reference in brackets to table numbers in IEC 60730-1, edition 3 for ease of correlation between parts 2 and the Part 1.

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

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

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

AUTOMATIC ELECTRICAL CONTROLS –

Part 1: General requirements

1 Scope and normative references

1.1 Scope

In general, this part of IEC 60730 applies to automatic **electrical controls** for use in, on, or in association with equipment for household and similar use. The equipment may use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof.

NOTE 1 Throughout this standard the word "equipment" means "appliance and equipment."

EXAMPLE 1 **Controls** for appliances within the scope of IEC 60335.

This International Standard is applicable to **controls** for building automation within the scope of ISO 16484.

This standard also applies to automatic **electrical controls** for equipment that may be used by the public, such as equipment intended to be used in shops, offices, hospitals, farms and commercial and industrial applications.

EXAMPLE 2 **Controls** for commercial catering, heating and air-conditioning equipment.

This standard is also applicable to individual **controls** utilized as part of a **control** system or **controls** which are mechanically integral with multifunctional **controls** having non-electrical outputs.

EXAMPLE 3 Independently mounted water valves, **controls** in smart grid systems and **controls** for building automation systems within the scope of ISO 16484-2.

This standard is also applicable to relays when used as **controls** for IEC 60335 appliances. Additional requirements for the safety and **operating values** of relays when used as **controls** for IEC 60335 appliances are contained in Annex U.

NOTE 2 These requirements are referred to in the scope of IEC 61810-1.

NOTE 3 This standard is intended to be used for the testing of any stand-alone relay which is intended to be used as a **control** of an appliance according to IEC 60335-1. It is not intended to be used for any other stand-alone relay, or to replace the IEC 61810 series of standards.

This standard does not apply to automatic **electrical controls** intended exclusively for industrial process applications unless explicitly mentioned in the relevant part 2 or the equipment standard.

〈A1〉This standard applies to **controls** powered by primary or secondary batteries, requirements for which are contained within the standard, including Annex V.〈A1〉

1.1.1 This International Standard applies to the inherent safety, to the **operating values**, **operating times**, and **operating sequences** where such are associated with equipment safety, and to the testing of automatic **electrical control** devices used in, or in association with, equipment.

This standard applies to **controls** using **thermistors**, see also Annex J.

This standard is also applicable to the **functional safety** of **low complexity safety related systems** and **controls**.

1.1.2 This standard applies to automatic **electrical controls**, mechanically or electrically operated, responsive to or controlling such characteristics as temperature, pressure, passage of time, humidity, light, electrostatic effects, flow, or liquid level, current, voltage, acceleration, or combinations thereof.

1.1.3 This standard applies to starting relays, which are a specific type of automatic **electrical control**, intended to switch the starting winding of a motor. Such **controls** may be built into, or be separate from, the motor.

NOTE Starting relays are tested as voltage sensing or current sensing controls.

1.1.4 This standard applies to **manual controls** when such are electrically and/or mechanically integral with **automatic controls**.

NOTE Requirements for manual switches not forming part of an **automatic control** are contained in IEC 61058-1.

1.1.5 This standard applies to a.c. or d.c. powered **controls** with a rated voltage not exceeding 690 V a.c. or 600 V d.c.

1.1.6 This standard does not take into account the **response value** of an **automatic action** of a **control**, if such a **response value** is dependent upon the method of mounting the **control** in the equipment. Where a **response value** is of significant purpose for the protection of the **user**, or surroundings, the value defined in the appropriate household equipment standard or as determined by the manufacturer shall apply.

1.1.7 This standard applies also to **controls** incorporating **electronic devices**, requirements for which are contained in Annex H.

1.1.8 This standard applies also to **controls** using NTC or PTC **thermistors**, requirements for which are contained in Annex J.

1.1.9 This standard applies to the electrical and **functional safety** of **controls** capable of receiving and responding to communications signals, including signals for power billing rate and demand response.

The signals may be transmitted to or received from external units being part of the **control** (wired), or to and from external units which are not part of the **control** (wireless) under test.

1.1.10 This standard does not address the integrity of the output signal to the network devices, such as interoperability with other devices unless it has been evaluated as part of the **control system**.

1.2 Normative references

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

IEC 60038, *IEC standard voltages*

〈C〉 EN 50525-2-11, *Electric cables – Low voltage energy cables of rated voltages up to and including 450/750 V (U_o/U) – Part 2-11: Cables for general applications – Flexible cables with thermoplastic PVC insulation*

EN 50525-2-21, *Electric cables – Low voltage energy cables of rated voltages up to and including 450/750 V (U_o/U) – Part 2-21: Cables for general applications – Flexible cables with crosslinked elastomeric insulation*

EN 55016-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus* (CISPR 16-1-1)

EN 60669-1:1999 + A1:2002 + A2:2008, *Switches for household and similar fixed-electrical installations – Part 1: General requirements* (IEC 60669-1:1998, mod. + A1:1999, mod.+ A2:2006, mod.)

EN 60730 Series, *Automatic electrical controls for household and similar use* (IEC 60730 series) 〈C〉

IEC 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*[1]
Amendment 1:2005
Amendment 2:2010

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60099-1, *Surge arresters – Part 1: Non-linear resistor type gapped arresters for a.c. systems*[2]

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*[3]
Amendment 1:2009

IEC 60127-1, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links*

IEC 60227-1, *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60245-1, *Rubber insulated cables – Rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 60269-1, *Low-voltage fuses – Part 1:General requirements*

IEC 60335-1:2010, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60364 (all parts), *Low-voltage electrical installations*

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1 There exists a consolidated edition 7.2:2011 including IEC 60065:2001 and its Amendments 1:2005 and 2:2010.

2 Withdrawn.

3 There exists a consolidated edition 4.1:2009 including IEC 60112:2003 and its Amendment 1:2009.

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification: Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors*

IEC 60384-17, *Fixed capacitors for use in electronic equipment – Part 17: Sectional specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors*

IEC 60417 (all parts), *Graphical symbols for use on equipment*

IEC 60423, *Conduit systems for cable management – Outside diameters of conduits for electrical installations and threads for conduits and fittings*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP code)*[4]
Amendment 1:1999

IEC 60539 (all parts), *Directly heated negative temperature coefficient thermistors*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*
Amendment 1:2010

IEC 60664-4, *Insulation coordination for equipment within low-voltage systems – Part 4: Consideration of high-frequency voltage stress*

IEC 60695-2-10, *Fire Hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test*

IEC 60738-1, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60738-1-1, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1-1: Blank detail specification – Current limiting application – Assessment level EZ*

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4 There exists a consolidated edition 2.1:2001 including IEC 60529:1989 and its Amendment 1:1999.

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60998-2-2, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*

IEC 60998-2-3, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-3: Particular requirements for connecting devices as separate entities with insulation-piercing clamping units*

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm^2 up to 35 mm^2 (included)*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3:2008, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
Amendment 1:2009

IEC 61000-4-28, *Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurements techniques – Variation of power frequency, immunity test*

IEC 61058-1, *Switches for appliances – Part 1: General requirements*

IEC 61210, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61249 (all parts), *Materials for printed boards and other interconnecting structures*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 61558-2-16, *Safety of transformers, reactors, power supply units and similar products for voltages up to 1 100 V – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units*

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

A1 IEC 62151, *Safety of equipment electrically connected to a telecommunication network* A1

IEC 62326 (all parts), *Printed boards*

A1 IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements* A1

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*[5]
Amendment 1:2008

CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

ISO 16484-2, *Building automation and control systems (BACS) – Part 2: Hardware*

5 There exists a consolidated edition 5.1:2009 including CISPR 14-1:2005 and its Amendment 1:2008.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Where the terms "voltage" and "current" are used, they imply the r.m.s. values, unless otherwise specified.

2.1 Definitions relating to ratings, voltages, currents, frequencies, and wattages

2.1.1
rated voltage, current, frequency or wattage
voltage, current, frequency or wattage assigned to a **control** by the manufacturer

Note 1 to entry: For three phase supply, the rated voltage is the line voltage.

2.1.2
rated voltage, current, frequency or wattage range
voltage, current, frequency or wattage ranges assigned to the **control** by the manufacturer and expressed by lower and upper values

2.1.3
working voltage
highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: **Transient overvoltages** are disregarded.

Note 2 to entry: Open-circuit conditions and normal operating conditions are taken into account.

2.1.4
extra-low voltage
ELV
nominal voltage not exceeding 50 V between conductors and between conductors and earth, or for three-phase connection not exceeding 50 V between line conductors and 29 V between line conductors and neutral

Note 1 to entry: These values were derived from IEC 60335-1:2010, Definition 3.4.1.

Note 2 to entry: In this standard **ELV**-levels for use in a specific application as specified in the relevant application standard may be declared for **controls** used in or with such applications for environmental conditions as specified by the application standard.

2.1.5
safety extra-low voltage
SELV
nominal voltage for use in a **SELV system** or **PELV system** between conductors and between conductors and earth, not exceeding 42 V between conductors, or in the case of three-phase circuits, not exceeding 24 V between conductors and neutral, the no-load voltage of the circuit not exceeding 50 V and 29 V, respectively, and which is provided by a battery or when obtained from higher voltage is provided by a **safety isolating transformer** or a converter with separate windings

Note 1 to entry: The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at its rated voltage.

Note 2 to entry: Converters with separate windings providing equivalent insulation are dealt with in IEC 61558-2-6 and IEC 61558-2-16.

Note 3 to entry: 〚C〛Void〚C〛

Note 4 to entry: Also see 2.1.20 **SELV system** and 2.1.21 **PELV system**.

2.1.6
safety isolating transformer
transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to **double insulation** or **reinforced insulation**, and which is intended to supply **safety extra-low voltage** circuits

2.1.7
same polarity
relationship between **live parts** such that an interconnection between them allows a flow of current through a load, and which current is thus limited by the load

2.1.8 Void

2.1.9
isolated limited secondary circuit
circuit from an isolated secondary winding of a transformer having a maximum capacity of 100 VA and an open-circuit secondary voltage rating not exceeding 1 000 V

2.1.10
pilot duty
class of **operation** in which the ultimate electrical load is controlled by an auxiliary means such as a relay or contactor

2.1.11
transient overvoltage
short duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60050-604:1987, 604-03-13]

2.1.12
rated impulse voltage
impulse withstand voltage assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against overvoltages

2.1.13
overvoltage category
numeral characterizing a **transient overvoltage** condition

Note 1 to entry: Overvoltage categories I, II, III, and IV are used. See Annex L.

2.1.14
exposed-conductive-part
conductive part of equipment, which can be touched and which is not normally live, but which can become live when **basic insulation** fails

Note 1 to entry: A conductive part of a **control** which can only become live through contact with an **exposed-conductive-part** which has become live, is not considered to be an **exposed-conductive-part** itself.

[SOURCE: IEC 60050-195:1998, 195-06-10, modified – Note 1 to entry has been added.]

2.1.15
(conductive) screen
〚C〛 *Text deleted* 〚C〛
conductive part that encloses or separates electric circuits and/or conductors

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-02-38]

2.1.16
(electrically) protective screen
〈C〉 *Text deleted* 〈C〉
conductive screen used to separate an electric circuit and/or conductors from hazardous-live-parts

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-06-17]

2.1.17
(electrically) protective screening
〈C〉 *Text deleted* 〈C〉
separation of electric circuits and/or conductors from **hazardous live parts** by an **electrically protective screen** connected to the protective **equipotential bonding system** and intended to provide protection against electric shock

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-06-18]

2.1.18
simple separation
separation between circuits or between a circuit and earth by means of **basic insulation**

[SOURCE: IEC 61140:2001, 3.23]

2.1.19
(electrically) protective separation
separation of one electric circuit from another by means of:

– **double insulation**, or
– **basic insulation** and **electrically protective screening** (**shielding**), or
– **reinforced insulation**

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-06-19]

2.1.20
SELV system
electrical system in which the voltage cannot exceed **ELV**:

– under normal conditions, and
– under single-**fault** conditions, including earth **faults** in other circuits

[SOURCE: IEC 61140:2001, 3.26.1]

2.1.21
PELV system
electrical system in which the voltage cannot exceed **ELV**:

– under normal conditions, and
– under single-**fault** conditions, except earth **faults** in other circuits

[SOURCE: IEC 61140:2001, 3.26.2]

2.2 Definitions of types of control according to purpose

2.2.1
electrical control
device used in, on or in association with an equipment for the purpose of varying or modifying the output from such equipment, and which embodies the aspects of **initiation**, **transmission** and **operation**

Note 1 to entry: Hereinafter, electrical control is referred to as "**control**".

Note 2 to entry: At least one of these aspects shall be electrical or electronic.

2.2.2
manual control
control in which the **initiation** is by **actuation** and in which the **transmission** and the **operation** are both direct and without any intentional time delay

2.2.3
automatic control
control in which at least one aspect is non-manual

2.2.4
sensing control
automatic control in which **initiation** is by an element sensitive to the particular **activating quantity** declared, for example, temperature, current, humidity, light, liquid level, position, pressure or velocity

2.2.5
thermally operated control
automatic control in which the **transmission** is by a thermal **prime mover**

2.2.6
thermostat
cycling temperature **sensing control**, which is intended to keep a temperature between two particular values under normal operating conditions and which may have provision for **setting by the user**

2.2.7
temperature limiter
temperature **sensing control** which is intended to keep a temperature below or above one particular value during normal operating conditions and which may have provision for **setting by the user**

Note 1 to entry: A **temperature limiter** may be of the automatic or of the manual reset type. It does not make the reverse **operation** during the normal **duty cycle** of the appliance.

2.2.8
thermal cut-out
temperature **sensing control** intended to keep a temperature below or above one particular value during abnormal operating conditions and which has no provision for **setting by the user**

Note 1 to entry: A **thermal cut-out** may be of the automatic or of the manual reset type.

Note 2 to entry: Normally a **thermal cut-out** will provide a **type 2 action**.

2.2.9 Void

2.2.10
energy regulator
self-cycling **control** which alters the energy to a load and which may incorporate means for **setting by the user** to change the average energy supplied

Note 1 to entry: The ratio of the on-time, to the on-plus-off-time, determines the average energy supplied.

2.2.11
time-based control
automated **control** in which the **transmission** is effected by a time-based **prime mover** or a time-based electrical circuit

2.2.12
electrically operated control
automatic control in which the **transmission** is effected by an electrical **prime mover** and in which the **operation** controls an electric circuit, and is without intentional significant time-delay

Note 1 to entry: An example is a relay.

Note 2 to entry: A slugged-relay may be either an **electrically operated control**, or a **time-based control** by agreement between testing authority and manufacturer.

2.2.13
timer
time-based control which requires **actuation** before the next cycle can take place

Note 1 to entry: During a cycle, it may require an external electrical or mechanical signal before moving from a rest position to allow the cycle to continue. An example is a programmer.

2.2.14
time switch
time-based control which continues with a subsequent cycle when the preceding one has been completed

Note 1 to entry: An example is a 24 h **control** on a storage heater.

2.2.15
motor protector
automatic control that is specifically intended to protect the windings of an electric motor from overheating

2.2.16
thermal motor protector
automatic control, built-in or on a motor, that is specifically intended to protect the motor against overheating due to running overload and failure to start

Note 1 to entry: The **control** carries motor current and is sensitive to motor temperature and current.

Note 2 to entry: The **control** is capable of being reset (either manually or automatically) when its temperature falls to the reset value.

2.2.17
electrically operated valve
automatic control in which the **transmission** is effected by an electrical **prime mover** and in which the **operation** controls the flow of a liquid or a gas

2.2.18
electrically operated mechanism
automatic control in which the **transmission** is effected by an electrical **prime mover** in which the **operation** controls a mechanical device

Note 1 to entry: An example is an electrically operated interlock for a spin dryer lid.

Note 2 to entry: An electric motor is not included in this definition.

2.2.19
operating control
control which starts or regulates the equipment during normal **operation**

2.2.20
protective control
control, the **operation** of which is intended to prevent a hazardous situation during abnormal **operation** of the equipment

2.2.21
multipurpose control
electrical control that can be classified and used for more than one purpose

Note 1 to entry: An example of a **multipurpose control** is a **thermostat** that can also be used as a **temperature limiter**.

2.2.22
multifunctional control
electrical control which incorporates more than one function

Note 1 to entry: An example of a **multifunctional control** is the combination of a **thermostat** and a humidistat.

2.2.23
system
control and **control** sensors and actuators as applied to an application or processes

2.3 Definitions relating to the function of controls

2.3.1
initiation
alteration to that aspect of a **control** which is required to produce **transmission** and **operation**

2.3.2
transmission
essential coupling between **initiation** and **operation** which is required to enable the **control** to fulfil its purpose

Note 1 to entry: This includes, but is not limited to, the use of:

a) communication lines/protocols;

b) additional hardware and/or software;

c) IR/RF **transmission**; or

all combinations of a) to c) via Internet using, for example, modems, portable telephones, etc.

2.3.3
operation
change in that aspect of a **control** which modifies the input to the equipment or part of the equipment

2.3.4
automatic action
that action of an **automatic control** in which the **transmission** and **operation** are produced by **initiation** which is not the result of **actuation**

2.3.5
slow-make slow-break automatic action
mode of **operation** where the rate of contact make and/or break is directly proportional to the rate of change of the **activating quantity**, or to the speed of movement of a **prime mover**

Note 1 to entry: This action may be applicable to either the make, or the break, or both.

2.3.6
manual action
that action of an **automatic control** or of a **manual control** in which the **transmission** and **operation** are produced by **initiation** which is the result of **actuation**

2.3.7
actuation
movement of the **actuating member** of the **control** by the **user**, by hand, by foot or by any other human activity

2.3.8
located position
position of the **actuating member** to which it will return if it is released after being moved slightly

2.3.9
intermediate position
any position of any **actuating member** which is adjacent to a **located position**, and in which the **actuating member** will remain and in which the **operation** of the **control** is intermediate

2.3.10
activating quantity
physical characteristic of a medium, the variation or stability of which is being sensed

2.3.11
operating value
value of the relevant temperature, pressure, current, etc. at which a **sensing control** operates on a rise or fall of the **activating quantity**

2.3.12
operating time
duration of time, or the difference of time, between any two functions, electrical or mechanical, occurring during the **automatic action** of a **time-based control**

2.3.13
operating sequence
intended sequence, order or pattern in which the **operation** of the electrical or mechanical functions of a **control** are intended to occur as a result of either an **automatic** or a **manual action** of a **control**

Note 1 to entry: It includes the pattern of opened or closed contacts in any **located position**, **intermediate position** or position of **setting by the equipment manufacturer** or **setting by the user**.

2.3.14
response value
operating value, the **operating time** or the **operating sequence** which relates a **control** to a particular equipment

2.3.15
trip-free
automatic action, with a reset **actuating member**, in which the **automatic action** is independent of manipulation or position of the reset mechanism

2.3.16
leakage current
all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of a device and earth or other exposed conductive surfaces of a device

2.3.17
setting
mechanical positioning of a part of a **control** in order to select an **operating value**

2.3.18
setting by the control manufacturer
any **setting** carried out by the **control manufacturer** which is not intended to be altered by the **equipment manufacturer**, the **installer** or the **user**

2.3.19
setting by the equipment manufacturer
any **setting** carried out by the **equipment manufacturer** which is not intended to be altered by the **installer** or the **user**

2.3.20
setting by the installer
any **setting** carried out by the **installer**, as instructed by the **equipment manufacturer** or the **control manufacturer**, and which is not intended to be altered by the **user**

2.3.21
setting by the user
any selection of an **operating value** by **actuation** performed by the **user**

2.3.22
set point
value selected by **setting**

2.3.23
adjustable set point
multiple values, within a declared range of values, which can be selected by **setting**

2.3.24
duty cycle
all automatic and **manual actions** involved in one start-to-finish **operation** of the controlled equipment

2.3.25
cycle of contact operation
one contact make and one subsequent contact break action, or one contact break and one subsequent contact make action

2.3.26
operating differential
difference between the upper and lower values of the **operating value**

2.3.27
adjustable differential
ability to change or alter the **operating differential** within rated limits by **operation** of a manually actuated mechanism

2.3.28
fixed differential
operating differential which cannot be changed from the manufacturer's **setting**

2.3.29
maximum working pressure
maximum rated pressure
declared maximum line or **system** working pressure to which the **control** or parts thereof may be subjected

2.3.30
maximum temperature
T_{max}
declared maximum continuous ambient temperature to which the **switch head** is intended to be exposed during normal **operation**

2.3.31
remotely actuated control function
function providing any **operation** by **control** devices through external means

Note 1 to entry: This includes, but is not limited to, the use of:

a) communication lines/protocols;

b) additional hardware and/or software;

c) IR/RF **transmission**; or

all combinations of a) to c) via Internet using, for example, modems, portable telephones, etc.

2.3.32
safety shut-down
change in the state of all electrical outputs so that all safety critical electrical outputs of the **control** will proceed to a safe condition including shut-down

2.4 Definitions relating to disconnection and interruption

Some **controls** may incorporate more than one form of circuit disconnection or interruption.

2.4.1
all-pole disconnection
for single-phase a.c. appliances and for d.c. appliances, disconnection of both supply conductors by a single switching action or, for appliances to be connected to more than two supply conductors, disconnection of all supply conductors, except the earthed (grounded) conductor, by a single switching action

Note 1 to entry: The protective earthing conductor is not considered to be a supply conductor.

2.4.2
full disconnection
contact separation in all supply poles other than earth so as to provide the equivalent of **basic insulation** between the supply mains and those parts intended to be disconnected

Note 1 to entry: There are electric strength and dimensional requirements.

Note 2 to entry: Where the number of poles on the **control** is equal to the number of supply poles of the appliance to which it is connected, **full disconnection** provides **all-pole disconnection**.

Note 3 to entry: See also Annex H.

2.4.3
micro-disconnection
adequate contact separation in at least one pole so as to provide functional security

Note 1 to entry: There is a requirement for the electric strength of the contact gap but no dimensional requirement.

Note 2 to entry: **Micro-disconnection** denotes that for non-**sensing controls** the function controlled by the disconnection is secure, and that for **sensing controls** is secure between the limits of **activating quantity** declared in requirement 36 of Table 1.

Note 3 to entry: See also Annex H.

2.4.4
micro-interruption
interruption of a circuit by contact separation, by a cycling action or by a non-cycling action which does not provide **full disconnection** or **micro-disconnection**

Note 1 to entry: There are no electric strength or dimensional requirements for the contact gap.

Note 2 to entry: See also Annex H.

2.4.5
OFF position
position providing a visible or implied indication of a **full disconnection** or **micro-disconnection**

2.4.6 See Annex H.

2.5 Definitions of types of control according to construction

2.5.1
integrated control
control which is dependent on its correct mounting and fixing in an equipment, and which can only be tested in combination with the relevant parts of the equipment

Note 1 to entry: The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Note 2 to entry: **Integrated control** also denotes a **control** which is part of a more complex **control** (electrical or non-electrical).

2.5.2
incorporated control
control intended for incorporation in, or on, an equipment, but which can be tested separately

Note 1 to entry: The fact that an **incorporated control** can be tested separately does not imply that it may not be tested in an equipment as specified in 4.3.1.1.

Note 2 to entry: The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Note 3 to entry: **Incorporated control** also denotes a **control** intended for incorporation in or on a more complex **control** (electrical or non-electrical).

2.5.3
in-line cord control
separately cased **control** intended to be connected to the supply and to the equipment by means of flexible cords, equipment inlets or socket-outlets, and is intended to be manually actuated

Note 1 to entry: A fuse in the plug is not regarded as a part of the **control**.

2.5.4
free-standing control
in-line cord control intended to stand on a table or on the floor

Note 1 to entry: It may be actuated by hand, by foot or by other similar human activity.

2.5.5
independently mounted control
control intended for permanent connection to **fixed wiring**, but intended to be mounted away from the controlled equipment

Note 1 to entry: It may be either:

– for surface mounting such as on to a wall;

– for flush mounting, such as into a wall cavity, when installation shall be possible from the front;

– for panel mounting, such as onto or into a **control** panel, when installation may be from the rear.

2.5.6
pull-cord actuated control
control intended to be mounted in, or on, an equipment and actuated by means of a **pull-cord**

2.5.7 to **2.5.10** See Annex H.

2.5.11
two-step actuation
sequential performance of two distinct movements of the **actuating member**

2.6 Definitions of type of automatic action of a control according to test procedure

2.6.1
type 1 action
automatic action for which the **manufacturing deviation** and the **drift** of its **operating value**, **operating time** or **operating sequence** have not been declared and tested under this standard

Note 1 to entry: A **type 1 action** is subclassified as specified in 6.4.

2.6.2
type 2 action
automatic action for which the **manufacturing deviation** and the **drift** of its **operating value**, **operating time** or **operating sequence** have been declared and tested under this standard

Note 1 to entry: A **type 2 action** is subclassified as specified in 6.4.

2.7 Definitions relating to protection against electric shock

2.7.1
live part
conductive part intended to be energized in **normal use**, including a neutral conductor, but by convention not a PEN conductor

2.7.1.1
hazardous live part
live part which, under certain conditions of external influences, can give an electric shock

2.7.2
class 0 control
control in which protection against electric shock relies upon **basic insulation**

Note 1 to entry: This implies that there are no means for the connection of accessible conductive parts, if any, to the **protective conductor** in the **fixed wiring** of the installation; reliance in the event of a **failure** of the **basic insulation** is placed upon the **environment**.

Note 2 to entry: 〚C〛See Annex ZB.〚C〛

Note 3 to entry: An earthing terminal is only allowed if it is for continuity or functional (as distinct from protective) purposes.

2.7.3
class 0I control
in-line cord control having at least **basic insulation** throughout and provided with an earthing terminal but with a **non-detachable cord** without earthing conductor, and a plug without earthing contact which cannot be introduced into a socket-outlet with earthing contact

Note 1 to entry: 〚C〛See Annex ZB.〚C〛

Note 2 to entry: An earthing terminal is only allowed if it is for continuity (as distinct from protective) purposes.

2.7.4
class I control
control in which protection against shock does not rely on **basic insulation** only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective (earthing) conductor in the **fixed wiring** of the installation in such a way that accessible conductive parts cannot become live in the event of a **failure** of the **basic insulation**

Note 1 to entry: This provision includes a **protective conductor** as part of the flexible cord or cable. When **class I controls** are fitted with a two-core flexible cord or cable; provided that it is fitted with a plug which cannot be introduced into a socket-outlet with earthing contact, the protection is then equivalent to that of class 0, but the earthing provisions of the equipment in all other respects should fully comply with the requirements of class I.

Note 2 to entry: **Class I controls** may have parts with **double insulation** or parts that provide protection against electric shock by **SELV** or **PELV**.

2.7.5
class II control
control in which protection against electric shock does not rely on **basic insulation** only, but in which additional protective precautions, such as **double insulation** or **reinforced insulation**, are provided, there being no provision for protective earthing or reliance upon installation conditions

Note 1 to entry: Such a **control** may be one of the types defined in 2.7.5.1 to 2.7.5.3.

Note 2 to entry: **Class II controls** may have parts that provide protection against electric shock by use of **SELV**.

Note 3 to entry: **Class II controls** cannot have parts that provide protection against electric shock by use of **PELV**, as such circuits require connection to an earthing terminal.

2.7.5.1
insulation-encased class II control
control having a durable and substantially continuous enclosure of insulation material which envelopes all metal parts, with the exception of small parts, such as name plates, screws and rivets, which are isolated from **live parts** by insulation at least equivalent to **reinforced insulation**

2.7.5.2
metal-encased class II control
control having a substantially continuous metal enclosure in which **double insulation** is used throughout, except for those parts where **reinforced insulation** is used, because the application of **double insulation** is manifestly impracticable

2.7.5.3
combination insulation-encased/metal-encased class II control
control which is a combination of the types described in 2.7.5.1 and 2.7.5.2

Note 1 to entry: The enclosure of an all-insulated **class II control** may form a part or the whole of the **supplementary insulation** or of the **reinforced insulation**. If a **control** with **double insulation** and/or **reinforced insulation** throughout has an earthing terminal or earthing contact, it is deemed to be of class 0I or class I construction.

〚C〛Note 2 to entry: See Annex ZB.〚C〛

2.7.6
class III control
control relying on limitation of voltage to **ELV** values as provision against electric shock for basic protection and

– with no provision for **fault** protection;

– which for supply are only connected to a **SELV system** or a **PELV system**, to form part of that **system**;

– where internal circuits do not operate at a higher level than **ELV**;

– where in case of a single **fault** within the **control** no steady state touch voltage may appear or be generated exceeding **ELV** level; and

– not provided with a means of connection for a **protective conductor**

2.7.7
detachable part
part which can be removed or opened without the aid of a **tool** and which does not comply with the test of 11.11.1.5

2.7.8
accessible part or accessible surface
part or surface which can be touched by the test finger of Figure 2, when the **control** is mounted as in **normal use**, and after **detachable parts** have been removed

2.7.9
functional insulation
insulation between **live parts** which have a potential difference between them, and which insulation is necessary for the correct **operation** of the **control** or controlled equipment (L-L)

Note 1 to entry: In 2.7.9 through 2.7.12, the following abbreviations are used:

L **live part**;

A **accessible part** (either conductive or an insulating surface);

I intermediate part.

2.7.10
basic insulation
insulation applied to **live parts** to provide basic protection against electric shock (L-A or L-I)

Note 1 to entry: **Basic insulation** includes insulation between **live parts** and:

– intermediate conductive parts or metal foil over intermediate insulating surfaces (class II situation);

– accessible conductive parts (class 0, 0I, I situations);

– conductive parts connected to accessible conductive parts (class 0, 0I, I situations);

– metal foil over accessible insulating surfaces (class 0 situation).

Note 2 to entry: This was formerly part of that insulation referred to as **functional insulation**.

2.7.11
supplementary insulation
independent insulation applied in addition to **basic insulation** in order to provide protection against electric shock in the event of a **failure** of **basic insulation** (I-A)

Note 1 to entry: It includes insulation between intermediate conductive parts, or metal foil over intermediate insulating surfaces and:

– accessible conductive parts (class II situation);

– conductive parts connected to accessible conductive parts (class II situation);

– metal foil over accessible insulating surfaces (class II situation).

2.7.12
reinforced insulation
single insulation **system** applied to **live parts**, which provides a degree of protection against electric shock equivalent to **double insulation** under the conditions specified in this standard (L-(I)-A)

Note 1 to entry: It includes insulation between **live parts** and:

– accessible conductive parts (class II situation);

– conductive parts connected to accessible conductive parts (class II situation);

– metal foil over accessible insulating surfaces (class II situation).

Note 2 to entry: The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as **supplementary insulation** or **basic insulation**.

2.7.13
double insulation
insulation comprising both **basic insulation** and **supplementary insulation** (class II situation)

2.7.14 See Annex H.

2.7.15
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

Note 1 to entry: The effectiveness of the **equipotential bonding** depends on the frequency of the current in the bonding.

Equipotential bonding is used to connect any conductive part of a building not forming part of the electrical installation and liable to introduce an electrical potential, generally the electric potential of the local earth (extraneous-conductive part) and any conductive part of **controls** or equipment or components in the installation which can be touched and which is not normally live but which can become live when **basic insulation** fails (**exposed-conductive-part**) to a main **equipotential bonding terminal** in the form of a bar, in order to bring these parts to the same potential. Parts to be connected to the **equipotential bonding system** include, for example, **protective conductors**, **PE** conductors, PEN conductors, earthing conductors, protective earthing terminals of **controls** or equipment, all conductive parts in a building, for example, metal tubing for water (drinking and waste), metallic bathtubs, the central heating system piping, any internal gas tubing (which is also required to be isolated from external gas tubing), earth connectors for antennas and telecommunication systems, all metal parts of the building used for construction like mats and iron, and conductors for lightning protection and depending on the installation system, the earth electrode. Requirements for **equipotential bonding** can be found in the IEC standards for the installation of buildings. These may be relevant for the installation of **controls** which consist of several component-parts (for example, sensors, actors, central **control** element, interface elements) connected in parallel to or via the fixed installation of the building.

[SOURCE: IEC 60050-195:1998, 195-01-10]

2.7.15.1
protective-equipotential-bonding
equipotential bonding for purposes of safety (protection against electric shock)

Note 1 to entry: Functional **equipotential bonding** is defined in [IEV 195-01-16].

[SOURCE: IEC 60050-195:1998, 195-01-15, modified – (protection against electric shock) has been added.]

2.8 Definitions relating to component parts of controls

2.8.1
sensing element
that part of the **control** which is intended to be exposed to the influences of the **activating quantity** to which the **automatic action** of a **sensing control** responds

2.8.2
switch head
complete **control**, except for any **sensing element**

Note 1 to entry: If by construction it is impossible to distinguish between the **switch head** and the **sensing element**, then the whole **control** is considered to be the **sensing element**.

2.8.3
actuating member
that part which is manually moved, pulled, pushed or turned to cause **initiation** of a **control** action, or for **setting by the user**

Note 1 to entry: The term "**actuating member**" does not include any device such as a set-screw used for **setting by the control manufacturer** if such a device is adequately locked against further movement, or if a **tool** is required for such **setting by the control manufacturer**.

2.8.4
actuating means
any part which connects the **actuating member** to the mechanism of the **control**

2.8.5
pull-cord
flexible **actuating member** which is pulled to cause **actuation**

2.8.6
prime mover
any device used to produce the mechanical energy required to provide the **transmission** for an **automatic control**, such as an **electrically operated control**, an **electrically operated valve**, an **electrically operated mechanism** or a **time-based control**

Note 1 to entry: It may be a mechanical storage device (for example, a clockwork spring), an electro-magnetic device (for example, an electric motor, or stepping solenoid), an electro-thermal device (for example, the heating element of an **energy regulator**) or any other mechanism producing mechanical energy.

2.8.7
clutch
mechanical device by which an **actuating member** can override either a **prime mover** or an **activating quantity**, causing or allowing the **initiation** or cancellation of an action

2.8.8
cover
cover plate
part which is accessible when the **control** is mounted as in **normal use** and which can be removed only with the aid of a **tool**

Note 1 to entry: It shall not require the use of a **special purpose tool** for its removal.

2.8.9
screwless fixed part (or component)
accessible part (or component) which, after attachment, installation, mounting or assembly into or onto an equipment or another component, or to a specially prepared support, is retained in position by positive means which do not depend on screws

Note 1 to entry: Disassembly or removal may require the use of a **tool**, either applied directly to the part (or component), or to obtain access to the retaining means.

Note 2 to entry: The following are some examples of parts which are not regarded as **screwless fixed parts or components**:

– parts of components fixed permanently by rivets, glueing or similar means;
– flat, push-on connectors;
– **screwless terminals**;
– standard plugs and socket-outlets;
– standard appliance couplers, even if such have additional latching devices to prevent a single action uncoupling;
– the replacement of a lamp in a bayonet type lampholder;
– twist-lug construction;
– friction-fit construction.

2.9 Definitions of types of terminals and terminations of controls

2.9.1
pillar terminal
terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws

Note 1 to entry: The clamping pressure may be applied directly by the shank of the screw, or through an intermediate clamping member to which pressure is applied by the shank of the screw (see Figure 11).

2.9.2
screw terminal
terminal in which the conductor is clamped under the head of the screw

Note 1 to entry: The clamping pressure may be applied directly by the head of the screw, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see Figure 10).

2.9.3
stud terminal
terminal in which the conductor is clamped under a nut

Note 1 to entry: The clamping pressure may be applied directly by a suitably shaped nut, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see Figure 10).

2.9.4
screwless terminal
terminal in which the connection of the conductor is achieved directly or indirectly by means of springs, wedges, eccentrics, cones or the like

Note 1 to entry: The following are not regarded as **screwless terminals**:

– terminals requiring the fixing of special devices to the conductors before clamping them in the terminal, for example, **flat push-on connectors**;

– terminals requiring wrapping of the conductors, for example, those with wrapped joints;

– terminals providing direct contact to the conductors by means of edges or points penetrating the insulation.

2.9.5
flat push-on connector
assembly of a **tab** and a **receptacle** enabling the connection, at will, of a core or conductor to a **control** or to another core or conductor

2.9.6
receptacle
female part of a **flat push-on connector** intended to be permanently attached to a core or conductor (see Figure 16)

2.9.7
tab
male part of a **flat push-on connector** (see Figures 14 and 15)

2.9.8
in-line tab
tab intended to be permanently attached to a core or conductor

2.9.9
tab forming part of a control
tab permanently attached to, or an integral part of, a **control**

2.9.10
termination
part by which a conductor can be connected to a **control** in such a way that its replacement requires either a **special purpose tool**, a special process or a specially prepared end of the conductor

Note 1 to entry: Soldering requires a **special purpose tool**. Welding requires a special process. A cable lug attached to a conductor is a specially prepared end.

2.9.11
solder termination
termination in which the conductor is secured by a mechanical means, and the circuit continuity is assured by solder

2.9.12
saddle terminal
terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts (see Figure 13a)

2.9.13
lug terminal
screw terminal or **stud terminal**, intended to clamp a cable lug or bar by means of a screw or nut (see Figure 13b)

2.9.14
mantle terminal
terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut

Note 1 to entry: The conductor is clamped against the base of the slot by a suitably shaped washer under the nut, by a central peg if the nut is a cap nut or equally effective means for transmitting the pressure from the nut to the conductor within the slot (see Figure 12).

2.9.15
equipotential bonding terminal
terminal provided on equipment or on a device and intended for the electric connection with the **equipotential bonding system**

[SOURCE: IEC 60050-195:1998, 195-02-32]

2.9.16
protective bonding terminal
terminal intended for **protective equipotential bonding** purposes

Note 1 to entry: Examples are a protective screen- or **PE**-terminal of a **control** or equipment.

2.9.17
protective conductor
PE
conductor provided for purposes of safety, for example, protection against electric shock

[SOURCE: IEC 60050-195:1998, 195-02-09]

2.10 Definitions relating to the connections to controls

2.10.1
external conductor
any cable, flexible cord, core or conductor, a part of which is external to an **in-line cord control**, an **independently mounted control** or to an equipment in or on which a **control** is mounted

Note 1 to entry: Such a conductor may be a supply lead, a function cord or interconnecting cord between different parts of an equipment; or it may form part of the **fixed wiring**.

2.10.2
fixed wiring
any **external conductor** which is permanently secured to the fabric of the building such that, in **normal use** at the point at which the conductor enters the equipment or **control**, there is no likelihood of any strain being applied to the conductor

Note 1 to entry: Such securing to the fabric of the building may be, for example, by the enclosing of conductors in conduit, burying cables in walls, adequately fixing cables or cords to walls or other surfaces, etc.

2.10.3
internal conductor
any cable, flexible cord, core or conductor which is neither an **external conductor**, nor an **integrated conductor**

Note 1 to entry: An example is a conductor inside the equipment to interconnect the **control** and the equipment.

2.10.4
integrated conductor
conductor which is inside a **control**, or is used to permanently interconnect terminals or **terminations** of a **control**

2.10.5
detachable cord
flexible external cord connected to a **control** or equipment by means of an equipment inlet, or plug and socket arrangement

2.10.6
non-detachable cord
flexible **external conductor** connected to, or assembled to, a **control** according to one of the methods in 2.10.6.1 to 2.10.6.4

2.10.6.1
type X attachment
method of attachment such that the cord can be easily replaced without **special-purpose tools**, using standard cords without any special preparation

2.10.6.2
type M attachment
method of attachment such that the cord can be easily replaced without **special purpose tools**, but is intended to use only a special cord, such as one with a moulded-on cord guard, or one with special prepared ends

Note 1 to entry: This attachment method does not apply if it is possible to fit a standard cord during **servicing** unless such is permitted by a particular equipment standard.

2.10.6.3
type Y attachment
method of attachment of the supply cord such that any replacement is intended to be made by the manufacturer, its service agent or a similar qualified person

2.10.6.4
type Z attachment
method of attachment such that the flexible cable or cord cannot be replaced without breaking or destroying a part of the **control**

2.10.7
flying lead
pigtail
wire or wires intended for the connection of the **control**, with one end permanently connected to the **control** by the **control manufacturer**

2.10.8
primary battery
cell
any kind of electrochemical **cell** in which the electrochemical reaction of interest is not reversible

Note 1 to entry: An example is an alkaline battery.

2.10.9
secondary battery
rechargeable cell
any kind of electrochemical **cell** in which the electrochemical reaction of interest is reversible

Note 1 to entry: A rechargeable battery is a group of two or more secondary **cells**.

Note 2 to entry: Examples of rechargeable batteries are nickel metal hydride (NiMH), lithium ion (Li-ion) etc.

2.11 Definitions relating to the performance of type 2 actions

2.11.1
manufacturing deviation
maximum difference of **operating value**, **operating time** or **operating sequence** which is claimed between any two **controls**, supplied by the manufacturer to a **unique type reference**, when tested as submitted and in the same manner

Note 1 to entry: The difference may be related to an absolute value if permitted by the appropriate subclause of Clause 15.

2.11.2
drift
maximum alteration of **operating value**, **operating time** or **operating sequence** of any one sample which can occur when it is tested under the conditions specified in this standard

Note 1 to entry: The alteration may be related to an absolute value, or combined with the **manufacturing deviation**, if permitted by the appropriate subclause of Clause 15.

2.12 Definitions relating to the requirements for creepage distances and clearances

2.12.1
clearance
shortest distance through air between two conductive parts, or between a conductive part and a metal foil in contact with a surface of insulating material

Note 1 to entry: The method of measurement is detailed in Annex B and Figure 17.

2.12.2
creepage distance
shortest distance along the surface of the insulating material between two conductive parts, or between a conductive part and a metal foil in contact with any **accessible surface** of insulating material

Note 1 to entry: The method of measurement is detailed in Annex B and Figure 17.

2.12.3 Void

2.12.4 Void

2.12.5 Void

2.12.6 Void

2.12.7 Void

2.12.8
pollution
any addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

2.12.9 Environment

2.12.9.1
macro-environment
environment of the room or other location in which the equipment is installed or used

2.12.9.2
micro-environment
immediate **environment** of the insulation which particularly influences the dimensioning of the **creepage distances**

2.12.9.3
pollution degree
numeral characterizing the expected **pollution** of the **micro-environment**

Note 1 to entry: **Pollution degrees** 1, 2, 3, and 4 are used. See Annex N.

2.13 Miscellaneous definitions

2.13.1
unique type reference
marking such that by quoting it in full to the manufacturer of the **control**, a replacement can be supplied which will be fully interchangeable with the original, electrically, mechanically, dimensionally and functionally

2.13.2
tool
screwdriver, a coin or any other object which may be used to operate a nut, a screw or similar part

2.13.3
special-purpose tool
tool which is unlikely to be readily available in a normal household, for example, a key for a hexagonal socket-headed screw

Note 1 to entry: **Tools** such as coins, screwdrivers and spanners intended to operate square, or hexagonal nuts, are not **special-purpose tools**.

2.13.4
normal use
use of the **control**, or its associated equipment, for the purpose for which it was made, and in the manner intended by the manufacturer

Note 1 to entry: **Normal use** includes any overload, or abnormal operating conditions specified in the equipment standard.

Note 2 to entry: **Normal use** does not include any process which is necessary to maintain the **control** or equipment in good order, even though this may be carried out by the **user** according to the manufacturer's instructions.

2.13.5
user maintenance
any periodic process necessary to maintain the **control**, or equipment, in good order, for which details are given in the manufacturer's instructions to the **user**

2.13.6
servicing
any process necessary to maintain a **control**, or equipment, in good order, that would be done by a competent person, such as in a workshop, by an electrician or by a service organization

Note 1 to entry: This includes replacing a flexible cord, thermal link or the like.

2.13.7
manufacturer servicing
servicing which can only be done by the manufacturer, or his accredited serviceman

Note 1 to entry: This may be due to the need for **special purpose tools**, or special instrumentation, and includes the **setting by the control manufacturer**.

2.13.8
failure
termination of the ability of an item to perform a required function

[SOURCE: IEC 60050-191:1990, 191-04-01]

2.13.9
fault
state of an item characterised by its inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

Note 1 to entry: "**Failure**" is an event, as distinguished from "**fault**", which is a state.

Note 2 to entry: After **failure**, the item has a **fault**.

Note 3 to entry: This concept as defined does not apply to items consisting of software only.

Note 4 to entry: A **fault** is often the result of a **failure** of the item itself, but may exist without prior **failure**.

[SOURCE: IEC 60050-191:1990, 191-05-01]

〈A1〉 **2.13.10**
smart grid
intelligent grid
electric power **system** that utilizes information exchange and **control** technologies, distributed computing and associated sensors and actuators, for purposes such as:

– to integrate the behaviour and actions of the network **users** and other stakeholders,
– to efficiently deliver sustainable, economic and secure electricity supplies

[SOURCE: IEC 60050-617:2011-10, 617-04-13] 〈A1〉

[A1] **2.13.11**
smart enabled control
control that is intended to interact with the **smart grid** and allows certain functions related to power billing rate or power demand response to be remotely controlled or enabled generally by communication with the power utility or by **user** remote interface

Note 1 to entry: For example, remote interface includes computer or smart phone. [A1]

2.14 Definitions relating to manufacturer and user

2.14.1
control manufacturer
manufacturer of the **control**

2.14.2
equipment manufacturer
manufacturer of equipment in which, on which, or together with which the **control** is used

[C] *Text deleted* [C]

2.14.3
installer
person qualified to install the **control** and possibly the associated equipment

2.14.4
user
one who uses the **control** with the aid of documentation (**user maintenance**) during its normal life

Note 1 to entry: The **user** is considered a layman.

2.14.5
low complexity safety-related systems or controls
safety related **system** or **control** in which

– the **failure** modes of each individual component are well defined;
– the behaviour of the **system** or **control** under **fault** conditions can be completely determined

2.15 Definitions pertaining to thermistors

See Annex J.

2.16 Definitions relating to the structure of controls using software

See Annex H.

2.17 Definitions relating to error avoidance in controls using software

See Annex H.

2.18 Definitions relating to fault/error control techniques for controls using software

See Annex H.

2.19 Definitions relating to memory tests for controls using software

See Annex H.

2.20 Definitions of software terminology – General

See Annex H.

2.21 Void

2.22 Definitions relating to classes of control functions

See Annex H.

2.23 Definitions relating to functional safety

See Annex H.

2.24 Definitions related to access to data exchange

See Annex H.

3 General requirements

Controls shall be so designed and constructed that in **normal use**, they function so as not to cause injury to persons or damage to surrounding property, even in the event of such carelessness as may occur in **normal use**.

In general, compliance is checked by carrying out the relevant tests specified in this standard and the appropriate part 2.

4 General notes on tests

Tests according to this standard are type tests.

〖C〗 *Text deleted* 〖C〗

4.1 Conditions of test

4.1.1 *Unless otherwise specified in this standard, the samples are tested as delivered, having been mounted as declared by the manufacturer, but, when significant, in the most unfavourable position.*

4.1.2 *If the test results are influenced by the room temperature, this shall be maintained at (20 ± 5) °C, except that in cases of doubt, it shall be maintained at (23 ± 2) °C, unless otherwise specified in a particular clause.*

4.1.3 ***Actuating members*** *are placed in the most unfavourably* ***located position****,* ***intermediate position*** *or position of* ***setting by the user****, unless other instructions are given in a particular clause.*

4.1.4 *Unless otherwise specified in this standard, the tests are carried out in the order of the clauses of this standard.*

See also Annex H.

4.1.5 *During the tests of this standard,* ***actuation*** *may be performed by test equipment if so desired, except for the high-speed tests of 17.12.*

4.1.6 *During and for the purpose of the tests of this standard, other than for the tests of 17.12, the* ***actuating means*** *can be used to actuate the* ***control****, if an* ***actuating member*** *is not supplied by the manufacturer.*

4.1.7 *The rates of temperature change declared in 7.2 and used in Clause 17 (that is* α_1*,* β_1*,* α_2 *and* β_2*) shall have test tolerances of* $\pm$*12 K/h.*

For other activating quantities, the minimum and/or maximum rates of change declared in requirement 37 of Table 1 and used in Clause 17 (that is α_1*,* β_1*,* α_2 *and* β_2*) shall have test tolerances as specified in the appropriate part 2.*

4.1.8 *In all tests, the measuring instruments or the measuring means shall be such as not to affect appreciably the value being measured.*

4.1.9 to **4.1.11** See Annex H.

4.2 Samples required

4.2.1 *One sample is used for the tests in Clauses 5 to 11 and 18 to 27, including the relevant annexes. A set of three samples is subjected to the remaining tests.*

If one sample does not comply with the tests of Clauses 12 to 17 inclusive, the test which caused the non-compliance, and those preceding which may have influenced the result of that test, are repeated on another set of identical samples, all of which shall then comply with the repeated tests.

The manufacturer may submit, together with the first set of samples, the additional set or sets which may be wanted should one sample not comply. The testing authority will then, without further request, test the additional samples, and will only reject if a further non-compliance occurs. If the additional sets of samples are not submitted at the same time, a non-compliance of one sample may entail a rejection.

NOTE In Canada and the USA, only one sample is used for the tests of Clauses 12 to 17 inclusive and the sample tested must comply.

4.2.2 Void

4.2.3 *Additional samples may be required for some destructive tests of this standard.*

4.2.4 ***Controls*** *which are intended to meet the requirements of more than one part 2 document shall, in general, be tested to each part 2 separately.*

NOTE By agreement between manufacturer and testing authority, requirements and tests which are common to more than one part 2, need only be checked once, unless the common tests can influence the results of any specific tests.

4.3 Instructions for test

4.3.1 According to submission

4.3.1.1 ***Controls****, if submitted in or with an equipment, may either be tested in or with the equipment, in which case they are classified as for declared specific load or tested separately, in which case they may be classified as for declared specific load, resistive load or resistive and inductive load. In either of the latter two cases, the current in the appropriate circuit when the equipment is operating under normal load is regarded as the rated current of the circuit.*

4.3.1.2 *For all* ***controls*** *submitted, in, on or with an equipment, all other relevant information as required by 7.2 may be obtained by inspection and measurement of the submitted equipment.*

4.3.1.3 ***Integrated controls*** *are classified as for declared specific load and are tested in the equipment, or part thereof, for which they are intended****.***

4.3.1.4 ***Controls*** *not submitted in or with an equipment are tested separately.*

4.3.1.5 ***Controls*** *for use with* ***non-detachable cords*** *are tested with the appropriate cord connected.*

4.3.2 According to rating

4.3.2.1 ***Controls*** *for a.c. only are tested with a.c. at rated frequency if declared; those for d.c. only are tested with d.c. and those for a.c./d.c. at the more unfavourable supply.*

4.3.2.2 ***Controls*** *for a.c. only, which are not declared for a rated frequency, are tested at either 50 Hz or 60 Hz, whichever is the more unfavourable.* ***Controls*** *with a rated frequency within a declared range other than 50 Hz to 60 Hz are tested at the most unfavourable frequency within the marked or declared range.*

4.3.2.3 *When testing* ***controls*** *intended for d.c. only, the possible influence of polarity on the* ***operation*** *of the* ***control*** *is taken into consideration.*

4.3.2.4 *For* ***controls*** *with different a.c. and d.c. ratings, the tests for Clauses 12, 13, 14 and 17, are made on two sets of samples, one being tested according to the a.c. rating, and the other according to the d.c. rating.*

NOTE At the option of the testing authority, a reduced number of tests can be made to cover the various ratings.

4.3.2.5 *Unless otherwise specified,* ***controls*** *declared for one or more voltage ranges shall be tested at the most unfavourable voltage within the declared range, and this voltage being multiplied by the factor indicated in the appropriate clause (see 4.3.2.7).*

4.3.2.6 *For* ***controls*** *marked or declared for more than one rated voltage or rated current, the tests of Clause 17 are made on sets of samples for each combination of rated voltage and rated current.*

NOTE At the option of the testing authority, a reduced number of tests can be made to cover the various ratings.

4.3.2.7 *For* ***controls*** *declared for a voltage range, tests are made on one set of samples at each limit of the range, unless the difference between the limits does not exceed 10 % of the mean value of the range, in which case the tests are made on one set of samples at the upper limit of the range.*

4.3.2.8 ***Controls*** *intended to be operated from a specific supply are tested with that specific supply.*

4.3.2.9 *A circuit for connection to the d.c. mains supply is classified as either a **SELV**/PELV circuit, **ELV** circuit or mains voltage circuit depending on the maximum operating voltage of the supply. This maximum operating voltage shall include consideration of the battery charging "float voltage" associated with the intended supply system, regardless of the marked voltage rating of the equipment.*

NOTE Float voltage is the constant voltage that is applied continuously to a voltaic **cell** to maintain the **cell** in a fully charged condition. Float voltage varies significantly with the chemistry and construction of the battery and ambient temperature.

4.3.2.10 ***Controls** powered by rechargeable batteries are additionally tested in accordance with Annex V.*

4.3.2.11 See Annex J.

4.3.3 According to protection against shock

4.3.3.1 *If in **class 0 control**, **class 0I control** or **class I control**, or in **controls** for class 0, class 0I or class I equipment, it is necessary to have parts with **double insulation** or **reinforced insulation**, such parts are checked for compliance with the appropriate requirements specified for **class II controls**.* 〖C〗*See Annex ZB.*〖C〗

4.3.3.2 *In any **class I control**, and in any **control** used in a class I equipment, unearthed accessible metal or accessible insulating surfaces shall be provided with insulation complying with the requirements for a **class II control** (see 9.1.1).*

4.3.3.3 *If in **class 0 control**, **class 0I control**, **class I control** or **class II controls**, or **controls** for class 0, class 0I, class I or class II equipment, it is necessary to have parts using **SELV**-circuits, such parts are also checked for compliance with the appropriate requirements specified for protection by use of **SELV** in 11.2.6.*

*If in **class I controls** or **controls** for class I equipment it is necessary to have parts using PELV-circuits, such parts are also checked for compliance with the appropriate requirements specified for protection by use of PELV in 11.2.6.* 〖C〗*See Annex ZB.*〖C〗

NOTE By definition (2.7.5) **class II controls** cannot use PELV-circuits.

4.3.4 According to manufacturing variants

4.3.4.1 ***Controls** which are otherwise identical but which may be set by the manufacturer, or which may, by the inclusion at the manufacturing stage of alternative components or parts produce various **operating values**, **operating times** or **operating sequences**, are for the purpose of this standard normally treated as a single submission. Normally, **controls** set to the most arduous condition will be sufficient. However, the testing authority may require extra samples, set to other values, where it can be clearly shown that these are necessary to allow approval of the whole range.*

4.3.4.2 *In these cases, due attention shall be paid to possible variations in **manufacturing deviation** and **drift** of any **operating value**, **operating time** or **operating sequence**, and, for **sensing controls**, to the minimum and maximum acceptable rates of rise and fall of the appropriate **activating quantity** which may be applicable to different parts of the range.*

4.3.5 According to purpose

4.3.5.1 *Multi-purpose **controls** shall, according to 6.3, in general be tested for each purpose separately. During the tests for any one purpose, the activating quantities and **prime movers** applicable to all other purposes, shall be maintained constant at the most arduous value or position within the declared range or ranges.*

4.3.5.2 *Such **controls** without an appropriate section of Clause 17 shall be tested in a manner agreed between the manufacturer and the testing authority so that the essential intended **operating values**, **operating times** and **operating sequences** are tested.*

4.3.5.3 *Any **control** with a purpose not classified in 6.3, or in the appropriate part 2, may be tested and approved to this standard, except for Clause 17. A test schedule for Clause 17 shall be based, wherever possible, on the intent of that clause and shall be agreed between the manufacturer and the testing authority.*

4.3.5.4 See Annex J.

5 Rating

5.1 Maximum rated voltage

The maximum rated voltage is 690 V.

〖C〗 The rated voltage of controls, having terminals intended to be directly connected to the supply mains single phase, shall cover usage at 230 V and to the supply mains multi phase, 400 V.〖C〗

5.2 Void

5.3 Compliance

Compliance with 5.1 and 5.2 is checked by the information requirements in Clause 7.

6 Classification

A **control** is classified:

6.1 According to nature of supply

6.1.1 Control for a.c. only

NOTE 1 A **control** for a.c. only can be used on a d.c. circuit provided that the current does not exceed 10 % of the rated current for a.c., or 0,1 A, whichever is smaller.

NOTE 2 Additional tests can be required to establish the d.c. rating.

6.1.2 Control for d.c. only.

6.1.3 Control for a.c. and d.c.

6.1.4 Control for specific supplies or multiple supplies.

6.1.5 Battery powered **control**.

6.2 According to type of load to be controlled by each circuit of the control

A **control** having more than one circuit need not have the same classification for each circuit.

6.2.1 Circuit for a substantially resistive load with a power factor not less than 0,95.

NOTE Such circuits can be used for an inductive load, provided that the power factor is not less than 0,8, and the inductive load does not exceed 60 % of the current rating for the resistive load. Such circuits can also be used for other reactive loads provided that the reactive current does not exceed 5 % of the rated resistive current, and that the load is not greater than 10 VA.

6.2.2 Circuit suitable for either a resistive load or for an inductive load with a power factor not less than 0,6 or a combination of both.

NOTE 1 An example is a circuit in a fan-heater which incorporates both a heating element and a motor.

NOTE 2 Circuits intended for inductive loads only can either be classified under 6.2.2 by declaring that the resistive load is equal to the inductive load, or may be classified as for a declared specific load.

6.2.3 Circuit for declared specific load.

NOTE Examples are circuits for tungsten filament or fluorescent lamp loads, highly inductive loads with a power factor of less than 0,6, capacitive loads, and contacts intended to be operated off load.

6.2.4 Circuit for a current less than 20 mA.

NOTE Examples are circuits for neon indicators and other signal lamps.

6.2.5 Circuit for a.c. motor load whose characteristics are defined by the **control** manufacturer's declaration.

6.2.6 Circuit for pilot load.

6.3 According to their purpose

A **control** may be classified for more than one purpose, in which case it is referred to as a multi-purpose **control**.

NOTE Any **manual action** of an **automatic control** or a separate **manual action** being integral with an **automatic control** is not classified according to 6.3.

6.3.1 – **thermostat**;

6.3.2 – **temperature limiter**;

6.3.3 – **thermal cut-out**;

6.3.4 Void

6.3.5 – **energy regulator**;

6.3.6 – **timer**;

6.3.7 – **time switch**;

6.3.8 – **manual control**;

6.3.9 – **sensing control** (other than one covered by 6.3.1 through 6.3.4);

6.3.10 – **electrically operated control**;

6.3.11 – **motor protector**;

6.3.11.1 – **thermal motor protector**;

6.3.12 – **electrically operated valve**;

6.3.13 – **electrically operated mechanism**;

6.3.14 – **protective control**;

6.3.15 – **operating control**.

NOTE Further classification can be found in the appropriate part 2.

6.4 According to features of automatic action

6.4.1 – **Type 1 action**;

6.4.2 – **Type 2 action**.

6.4.3 Type 1 actions and **type 2 actions** are further classified according to one or more of the following constructional or operational features:

NOTE 1 These further classifications are only applicable if the relevant declarations have been made and any appropriate tests completed.

NOTE 2 An action providing more than one feature may be classified by a combination of the appropriate letters, for example, type 1.C.L. or type 2.A.E.

NOTE 3 A **manual action** is not classified according to 6.4.3.

6.4.3.1 – **full disconnection** on **operation** (type 1.A or 2.A);

6.4.3.2 – **micro-disconnection** on **operation** (type 1.B or 2.B);

6.4.3.3 – **micro-interruption** on **operation** (type 1.C or 2.C);

6.4.3.4 – a **trip-free** mechanism which cannot even momentarily be reclosed against the **fault** (type 1.D or 2.D);

6.4.3.5 – a **trip-free** mechanism in which the contacts cannot be prevented from opening or maintained closed against a continuation of the **fault** (type 1.E or 2.E);

NOTE An example is a current-**sensing control** which has to be reclosed or can be reclosed momentarily to detect that the excess current **fault** still exists.

6.4.3.6 – an action which can only be reset by the use of a **tool** (type 1.F or 2.F);

6.4.3.7 – an action which is not intended to be reset under electrically loaded conditions (type 1.G or 2.G);

6.4.3.8 – a **trip-free** mechanism in which the contacts cannot be prevented from opening and which may automatically be reset to the "closed" position after normal **operation** conditions have been restored if the reset means is held in the "reset" position (type 1.H or 2.H);

6.4.3.9 – a **trip-free** mechanism in which the contacts cannot be prevented from opening and the **control** is not permitted to function as an automatic reset device if the reset means is held in the "reset" or "on" position (type 1.J or 2.J);

6.4.3.10 – for sensing actions, no increase in the **operating value** as the result of a breakage in the **sensing element**, or in parts connecting the **sensing element** to the **switch head** (type 1.K or 2.K);

6.4.3.11 – an action that does not require any external auxiliary energy source of electrical supply for its intended **operation** (type 1.L or 2.L);

6.4.3.12 – an action which operates after a declared ageing period (type 1.M or 2.M).

6.4.3.13 See Annex H.

6.5 According to the degree of protection and control pollution degree

6.5.1 According to degrees of protection provided by enclosures against ingress of solid objects and dust (see IEC 60529):

IP0X, IP1X, IP2X, IP3X, IP4X, IP5X, IP6X.

6.5.2 According to degree of protection provided by enclosures against harmful ingress of water (see IEC 60529):

IPX0, IPX1, IPX2, IPX3, IPX4, IPX5, IPX6, IPX7, IPX8.

NOTE 1 A **control** intended for use in a particular **environment** can be used for a different **environment** if the appropriate provisions, if any, are made in the equipment.

NOTE 2 Preferred combinations of degrees of protection are according to 6.5.1 and 6.5.2:

First characteristic numeral **Protection against ingress of foreign bodies**	**Second characteristic numeral** **Protection against ingress of water**								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0	IP00								
1									
2	IP20	IP21							
3									
4		IP41		IP43	IP44				
5					IP54	IP55			
6						IP65		IP67	IP68

6.5.3 According to the **pollution degree** or **pollution degrees** for which the **control** is declared. See Annex N.

NOTE It is possible that when a **control** is mounted in accordance with the manufacturer's declaration, different parts of the **control** can be in **macro-environments** having different **pollution degrees**.

6.6 According to method of connection

6.6.1 **Control** with at least one terminal intended for the connection of **fixed wiring**.

Text deleted

6.6.2 **Control** with at least one terminal intended for the connection of a flexible cord.

A **control** may be classified under both 6.6.1 and 6.6.2.

6.6.3 **Control** without any terminals intended for the connection of an **external conductor**.

This type of **control** is intended for the connection of only integrated or **internal conductors**.

6.6.4 **Control** intended for the connection of a **primary battery**.

6.6.5 Control intended for the connection of a **secondary battery** (**rechargeable cell**).

6.7 According to ambient temperature limits of the switch head

6.7.1 **Control** with a **switch head** for use in an ambient temperature between a minimum value (T_{min}) of 0 °C, and a maximum value ($\boldsymbol{T_{max}}$) of 55 °C.

6.7.2 **Control** with a **switch head** intended to be used in an ambient temperature having a maximum value ($\boldsymbol{T_{max}}$) other than 55 °C but no less than 30 °C, or a minimum value (T_{min}) lower than 0 °C, or both.

NOTE Preferred values of $\boldsymbol{T_{max}}$ are 30 °C, 55 °C, 70 °C, 85 °C, 105 °C, 125 °C, 150 °C. Preferred values of T_{min} are 0 °C, –10 °C, –20 °C, –30 °C, and –40 °C.

Values differing from these preferred values are possible.

6.8 According to protection against electric shock

6.8.1 For an **integrated control**:

NOTE An **integrated control** is not classified but takes the classification of the equipment with which it is integrated.

6.8.2 For an **incorporated control** for use in:

6.8.2.1 – class 0 equipment 〖C〗 (see Annex ZB) 〖/C〗;

6.8.2.2 – class 0I equipment 〖C〗 (see Annex ZB) 〖/C〗;

6.8.2.3 – class I equipment;

6.8.2.4 – class II equipment;

6.8.2.5 – class III equipment.

NOTE 1 For coordination of electrical equipment class 0, class I, class II and class III, see IEC 61140, and for protective provisions within an electrical installation, see IEC 60364.

NOTE 2 A **control** intended for incorporation in a particular class of equipment may be used for a different class if appropriate provisions are made in the equipment.

6.8.3 For an **in-line cord control**, a freestanding **control**, or an **independently mounted control**:

6.8.3.1 – of class 0 〖C〗 (see Annex ZB) 〖/C〗;

6.8.3.2 – of class 0I 〖C〗 (see Annex ZB) 〖/C〗;

6.8.3.3 – of class I;

6.8.3.4 – of class II;

6.8.3.5 – of class III.

NOTE 1 For coordination of electrical equipment class 0, class I, class II and class III, see IEC 61140, and for protective provisions within an electrical installation, see IEC 60364.

NOTE 2 A **control** intended for incorporation in a particular class of equipment may be used for a different class if appropriate provisions are made in the equipment.

6.8.4 Controls using **SELV** or PELV for protection against electric shock

6.8.4.1 Controls using **SELV**-circuit(s), and if applicable, the information declared in Table 1, requirement 86

6.8.4.2 Controls using PELV-circuit(s), and if applicable, the information declared in Table 1, requirement 86

6.9 According to circuit disconnection or interruption:

6.9.1 – **full disconnection**;

6.9.2 – **micro-disconnection**;

6.9.3 – **micro-interruption**;

6.9.4 – **all-pole disconnection**;

6.9.5 – See Annex H.

NOTE 1 Some equipment standards require **full disconnection**, others permit either **full disconnection** or **micro-disconnection**; some only require **micro-interruption**.

NOTE 2 Different actions of a **control** can provide different circuit disconnections or interruptions.

6.10 According to number of cycles of actuation (M) of each manual action

Preferred values are:

6.10.1 – 100 000 cycles;

6.10.2 – 30 000 cycles;

6.10.3 – 10 000 cycles;

6.10.4 – 6 000 cycles;

6.10.5 – 3 000 cycles [1);]

6.10.6 – 300 cycles [1);]

6.10.7 – 30 cycles [1).]

[1)] Applicable only to actions of **controls** for specific equipment and applications such as voltage-tap **controls**, summer/winter **controls** for water heaters and where permitted by the appropriate equipment standard.

NOTE For **controls** with more than one **manual action**, a different value can be declared for each. If a **control** has more than one intended **"OFF" position**, then a cycle of **actuation** is regarded as a movement from one "OFF" position to the next **"OFF" position**.

6.11 According to number of automatic cycles (A) of each automatic action

Preferred values are:

6.11.1 – 300 000 cycles;

6.11.2 – 200 000 cycles;

6.11.3 – 100 000 cycles;

6.11.4 – 30 000 cycles;

6.11.5 – 20 000 cycles;

6.11.6 – 10 000 cycles;

6.11.7 – 6 000 cycles;

6.11.8 – 3 000 cycles [1)];

6.11.9 – 1 000 cycles [1)];

6.11.10 – 300 cycles [2)];

6.11.11 – 30 cycles [2)4)];

6.11.12 – 1 cycle [3)].

1) Not applicable to **thermostats** or to other fast cycling actions.

2) Applicable only to manual reset.

3) Applicable only to actions which require the replacement of a part after each **operation**.

4) Can only be reset during **manufacturer servicing**.

NOTE For **controls** having more than one **automatic action**, a different value can be declared for each.

6.12 According to temperature limits of the mounting surface of the control

6.12.1 **Control** suitable for mounting on a surface which is not more than 20 K above the ambient temperature classified in 6.7.

6.12.2 **Control** suitable for mounting on a surface which is more than 20 K above the ambient temperature classified in 6.7.

NOTE An example of such a **control** is one mounted on a compressor unit in a refrigerator, where the mounting surface can be 150 °C, although the **sensing element** is at a temperature of –10 °C, and the ambient temperature is only 30 °C.

6.13 According to value of proof tracking index (PTI) for the insulation material used

6.13.1 – material of material group IIIb with a PTI of 100 and up to but excluding 175;

6.13.2 – material of material group IIIa with a PTI of 175 and up to but excluding 400;

6.13.3 – material of material group II with a PTI of 400 and up to but excluding 600;

6.13.4 – material of material group I with a PTI of 600 and over.

6.14 According to period of electrical stress across insulating parts supporting live parts and between live parts and earthed metal

6.14.1 – short period;

6.14.2 – long period.

NOTE Long periods of electrical stress are considered to exist if the **control** is used in equipment for continuous use; and also for the supply side of a **control** in any other equipment unlikely to be disconnected from the supply by the removal of a plug or by the **operation** of a **control** providing **full disconnection**.

6.15 According to construction:

6.15.1 – **integrated control**;

6.15.2 – **incorporated control**;

6.15.3 – **in-line cord control**;

6.15.4 – **free-standing control**;

6.15.5 – **independently mounted control** for:

6.15.5.1 – surface mounting;

6.15.5.2 – flush mounting;

6.15.5.3 – panel mounting.

6.15.6 See Annex J.

6.16 According to ageing requirements (Y) of the equipment in which, or with which, the control is intended to be used

6.16.1 – 60 000 h;

6.16.2 – 30 000 h;

6.16.3 – 10 000 h;

6.16.4 – 3 000 h;

6.16.5 – 300 h;

6.16.6 – 15 h.

NOTE **Controls** which operate during the heating or endurance tests of the equipment standard are not classified according to 6.16.6.

6.17 According to use of the thermistor

See Annex J.

6.18 According to classes of control functions

See Annex H.

7 Information

7.1 General requirements

The **control manufacturer** shall provide adequate information to confirm:

– that a suitable **control** can be selected;

– that the **control** can be mounted and used in a manner that will enable it to meet the requirements of this standard; and

– that the relevant tests can be performed to determine compliance with this standard.

7.2 Methods of providing information

7.2.1 Information shall be provided using one or more of the following methods. The information required for **controls** and the appropriate method for providing this information shall be as indicated in Table 1.

NOTE 1 It is not intended that Table 1 itself necessarily be the actual form used to communicate between manufacturer and test house.

– By marking (C) – this information shall be provided by marking on the **control** itself, except that, in the case of an **integrated control**, such marking can be on an adjacent part of the equipment, provided that it is clear that it refers to the **control**.

NOTE 2 Information provided by marking (C) can also be included in documentation (D,E).

– By documentation [A1] on hard copy [A1] (D) – this information shall be provided for the **user** or **installer** of the **control**, and shall consist of legible instructions. Each **control** shall be accompanied by such instructions. Instruction sheets and other texts required by this standard shall be written in the official language(s) of the country in which the **control** is to be sold.

For **controls** intended to be exclusively delivered to the **equipment manufacturer**, the instruction sheet may be replaced by a leaflet, letter or drawing, etc. It is not necessary for each **control** to be accompanied by such a document.

[A1] – By documentation on electronic media on internal or external memory (E) – this information is as alternative to (D).[A1]

– By declaration (X) – this information shall be provided for the testing authority for purposes of test and in a manner agreed between testing authority and manufacturer. It may, for example, be provided by a marking on the **control**, by a leaflet, letter or drawing or, in the case of a **control** submitted in, on or with an equipment, by measurement or inspection of the submitted equipment. This information should also be provided to the **equipment manufacturer**, as appropriate.

7.2.2 Information which is indicated as being required by marking (C) or by documentation [A1] (D,E) [A1] shall also be provided for the testing authority in an agreed manner if so requested by the testing authority.

7.2.3 For **controls** submitted in, on or with an equipment, the requirement for documentation [A1] (D,E) [A1] is replaced by declaration (X).

7.2.4 For an **integrated control** forming part of a more complex **control**, the marking relating to the **integrated control** may be included in the marking of the more complex **control**.

7.2.5 The requirement for documentation [A1] (D,E) [A1] is considered to be met if such information has been provided by marking (C).

7.2.5.1 The requirement for declaration (X) is considered to be met if such information has been provided by either documentation [A1] (D,E) [A1] or by marking (C).

7.2.6 Except as indicated in 7.4, for **integrated controls** all information is provided by means of declaration (X).Unless otherwise indicated in a part 2, for **incorporated controls**, the only marking required is the manufacturer's name or trade mark and the **unique type reference**, if other required marking is provided by documentation [A1] (D,E) [A1]. For **incorporated controls** declared under [A1] requirement [A1] 50, see the explanation of documentation [A1] (D,E) [A1] contained in 7.2.1.

7.2.7 For **controls** that are neither integrated nor incorporated, where lack of space prevents legible marking as specified, the **control** shall be marked with the manufacturer's name (or trade mark) and the **unique type reference** only. The other marking required shall be included in documentation [A1] (D,E). [A1]

7.2.8 Additional marking or information is allowed, provided that it does not give rise to misunderstanding.

7.2.9 When symbols are used, they shall be as follows:

Amperes	A
Volts	V
Watts	W
Volts-amperes	VA
Alternating current (single-phase)	~ IEC 60417-5032 (2002-10)
Alternating current (three-phase)	3~
Alternating current (three-phase with neutral)	3N~
Direct current	IEC 60417-5031 (2002-10)
Class II construction	IEC 60417-5172 (2003-02)
Class III control	III IEC 60417-5180 (2003-02)
Ambient temperature limits of **switch head** T	(The letter T preceded by a minus sign and the numerical value of the lower temperature if T_{min} less than 0 °C, or followed by the numerical value of the higher temperature if $\boldsymbol{T_{max}}$ other than 55 °C.)
Rated current of the appropriate fuse in amperes	IEC 60417-5016 (2002-10)
Frequency	Hz
Earthing terminal	IEC 60417-5019 (2006-08)
Functional earthing	IEC 60417-5018 (2011-07)

For identification of the degree of protection provided by enclosures, the symbols shown in 6.5 shall be used.

NOTE 1 Information about rated current and rated voltage can be provided by using figures alone, the figure for the rated current preceding or above that for the rated voltage and separated from it by a line. For circuits for resistive load and inductive loads, the rated current for inductive load is placed between parentheses and immediately following the rated current for resistive load. The symbol for the nature of the supply is placed after the current and voltage.

Current, voltage and nature of supply can be indicated as follows:

$$16\ (3)\ \text{A}\ 250\ \text{V}\ \sim \quad \text{or} \quad 16\ (3)\ /\ 250\ \sim \quad \text{or} \quad \frac{16\ (3)}{250}\ \sim$$

NOTE 2 The following are examples of ways to provide information about the temperature limits of a **control**:

– 20T 30 (meaning minus 20 °C up to plus 30 °C);

– T85 (meaning 0 °C up to plus 85 °C).

NOTE 3 Information concerning declared specific loads can be given by reference to drawings or to types, for example:

"Electric motor, drawing No. ..., part list No. ..., made by..." or "5 × 80 W fluorescent".

Table 1 (7.2 of edition 3) – Required information and methods of providing information *(1 of 4)*

Information	Clause or subclause	Method
1 Manufacturer's name or trade mark	7.2.6	C
2 **Unique type reference** [a]	2.11.1, 2.13.1, 7.2.6	C
3 Rated voltage or rated voltage range in volts (V)	2.1.2, 4.3.2 14.4,	C
4 Nature of supply unless the **control** is for both a.c. and d.c., or unless the rating is the same for a.c. and d.c.	4.3.2, 6.1	C
5 Frequency if other than for range 50 Hz to 60 Hz inclusive	4.3.2	C
6 Purpose of **control**	2.2, 4.2.4, 4.3.5, 6.3, 17.16	[A1] D or E [A1]
6a Construction of **control** and whether the **control** is electronic	6.15, Annex H, H.2.5.7	[A1] X [A1]
7 [C] The type of load and rated current [b] [C]	6.2, 14, 17, 23.1.1	C
15 Degree of protection provided by enclosure [c]	6.5.1, 6.5.2 11.5	C
17 Which of the terminals are suitable for the connection of **external conductors**, and if they are suitable for line or neutral conductors, or both	6.6, 7.4.2 7.4.3	C
18 Which of the terminals for **external conductors** are for a wider range of conductor sizes than those indicated in Table 3.	10.1	[A1] D or E [A1]
19 For **screwless terminals**, the method of connection and disconnection, [A1] if not readily identifiable [A1]	10	D
20 Details of any special conductors which are intended to be connected to the terminals for **internal conductors**	10.2.1	[A1] D or E [A1]
21 Maximum temperature of terminals for **internal conductors** and terminals for **external conductors** of **incorporated** and **integrated controls**, if higher than 85 °C	14	X
22 Temperature limits of the **switch head**, if T_{min} lower than 0 °C or $\boldsymbol{T_{max}}$ other than 55 °C	6.7, 14.5 14.7, 17.3	C
23 [C] if more than 20 K above $\boldsymbol{T_{max}}$ [C]	6.12.2, 14.1, 17.3	C
24 Classification of **control** according to protection against electric shock	6.8	X
25 For **class II controls**, the symbol for Class II construction	7.3	C
26 Number of cycles of **actuation** (M) for each **manual action**	6.10, 17.10, 17.11	X
27 Number of automatic cycles (A) for each **automatic action**	6.11, 17.8, 17.9	X
28 Ageing period (Y) for **controls** with type 1M or 2M action	6.16, 17.6	X

Table 1 *(2 of 4)*

Information	Clause or subclause	Method
29 Type of disconnection or interruption provided by each circuit	2.4.1, 2.4.2, 2.4.3, 2.4.4, 6.9	X
30 PTI of materials used for insulation	6.13, Table 23, Footnote b, Table 24, Footnote d, 21.2.7	X
31 Method of mounting **control** [e]	11.6	D
31a Method of providing earthing of **control**	7.4.3, 9, 9.1.1, 9.1.2	D
32 Method of attachment for **non-detachable cords** [f]	10.1, 11.7	A1 D or E A1
33 Intended transportation condition of **control** [g]	16.1	X
34 Details of any limitation of **operating time** [h]	14, 17	A1 D or E A1
35 Period of electric stress across insulating parts	6.14	X
36 Limits of **activating quantity** for any **sensing element** over which **micro-disconnection** is secure (see also Clause H.7, item36)	11.3.2	X
37 Minimum and/or maximum rates of change of actuating quantity, or minimum and/or maximum cycling rates for a **sensing control** [i]	4.1.7, 15, 17	X
38 Values of overshoot of **activating quantity** for **sensing controls** which are necessary for correct action, or which can be used for test purposes	17	X
39 **Type 1 action** or **type 2 action**	6.4	A1 D or E A1
40 Additional features of **type 1 action** or **type 2 actions**	6.4.3, 11.4	A1 D or E A1
41 **Manufacturing deviation** and condition of test appropriate to deviation	2.11.1, 11.4.3, 15, 17.14	X
42 **Drift**	2.11.2, 11.4.3, 15, 16.2.4	X
43 Reset characteristics for cut-out action [j]	6.4	A1 D or E A1
44 If a **control** is either to be hand-held or is intended for a hand-held equipment		X
45 Any limitation to the number or distribution of flat push-on **receptacles** which can be fitted	10.2.4.4	A1 D or E A1
46 Any **type 2 action** shall be so designed that the **manufacturing deviation** and **drift** of its **operating value**, **operating time** or **operating sequence** is within the limit declared in requirements 41, 42, and 46 of Table 1	11.4.3	A1 D or E A1
47 Extent of any **sensing element**	2.8.1	A1 X A1
48 **Operating value** (or values) or **operating time**	2.3.11, 2.3.12, 6.4.3.10, 11, 14, 15.6,17	D
49 **Control pollution degree**	6.5.3	A1 D or E A1
50 **Control** intended to be delivered exclusively to the **equipment manufacturer**	7.2.1, 7.2.6	X
51 Glow wire test temperatures	21.2.1, 21.2.2, 21.2.3, and 21.2.4	X
52 to 60 See Annex H		
61 to 65 See Annex J		
66 to 74 See Annex H		

Table 1 *(3 of 4)*

Information	Clause or subclause	Method
75 **Rated impulse voltage**	2.1.12, 20.1	[A1] D or E [A1]
76 Type of printed circuit board coating	Annex P or Annex Q	X
77 Temperature for the ball pressure test	21.2.1, 21.2.2, 21.2.3 and 21.2.4	[A1] X [A1]
78 Maximum declared torque on single bush mounting using thermoplastic material	Table 20, Footnote a	[A1] D or E [A1]
79 **Pollution degree** in the **micro-environment** of the **creepage distance** or **clearance** if cleaner than that of the **control**, and how this is designed	Table H.24	[A1] X [A1]
80 **Rated impulse voltage** for the **creepage distance** or **clearance** if different from that of the **control**, and how this is ensured	Table H.24	[A1] D or E [A1]
81 The values designed for tolerances of distances for which the exclusion from **fault** mode "short" is claimed	Table H.24	[A1] X [A1]
82 See Annex J		
85 For **class III controls**, the symbol for Class III construction	7.4.6	C
86 For **SELV** or PELV circuits, the **ELV** limits realized	2.1.5, T.3.2	[A1] X [A1]
87 Value of accessible voltage of **SELV**/PELV circuit, if different from 8.1.1, product standard referred to for the application of the **control**, in which standard(s) the accessible **SELV**/PELV level(s) is (are) given	2.1.4, 6.8.4.1, 6.8.4.2, 8.1.1.1	[A1] X [A1]
88 See Annex U		
89 Emission tests and groups as declared according to CISPR 11	23.2, H.23.1.2	X
90 Immunity tests for **protective controls** for use in accordance with IEC 60335 appliances	Table H.13	X
91 to 94 See Annex H		
95 [AC1] Maximum short circuit current as declared [AC1]	11.3.5.2.1 b)	[A1] X [A1]
[C] Z1 EMC standard/test method	23.1	X
Z2 Declared voltage and declared current for the purposes of EMC emission tests[Za]	23.1.1	D [C]
[A1] 96 Overcurrent protective device external to the **control**	11.14	D or E
97 For **incorporated controls** or **integrated controls**, whether the overload test shall be done at control level	27.5.3	X
98 Maximum altitude at which the **control** can be used if greater than 2 000 m	20.1	X [A1]

[a] The **unique type reference** shall be such that, when it is quoted in full, the manufacturer of the **control** can supply a replacement which will be fully interchangeable with the original electrically, mechanically, dimensionally, and functionally.

It may comprise a series type reference with other marking, such as voltage rating or an ambient temperature marking, which together provide a **unique type reference**.

[b] [C] For each circuit of the control, the type of load and rated current. For controls with more than one circuit, it shall be made clear to which circuit or terminal the information applies. For circuits for resistive and inductive loads, the rated current, or the rated load in VA, at power factors as indicated in Table 14 (17.2.1 of the 3rd edition). [C]

[c] The marking (C) requirement does not apply to **controls** or parts thereof classified as IP00, IP10, IP20, IP30 and IP40.

[d] [C] Void [C]

Table 1 *(4 of 4)*

[e] If, for **independently mounted controls**, it is necessary to take special precautions when installing or using the **control**, these details shall be given in an instruction sheet accompanying the **control**.

Special precautions may be necessary, for example, for flush mounting **independently mounted controls**. In order to ensure that, after building-in, the conditions necessary to meet the requirements of this standard are achieved, the instruction sheet for such **controls** shall include clear information concerning:

– the dimensions of the space to be provided for the **control**;

– the dimensions and position of the means for supporting and fixing the **control** within this space;

– a minimum clearance between the various parts of the **control** and the surrounding parts of the fitment;

– the minimum dimensions of ventilating openings and their correct arrangements;

– the connection of the **control** to the supply and the interconnection of separate components, if any.

If the supply conductors of a **control** can come into contact with parts of a terminal block or a compartment for **fixed wiring**, and these parts have, under conditions of **normal use**, a temperature exceeding that specified in Table 13, the instruction sheet shall also state that the **control** shall be connected by means of conductors having the appropriate T rating (see Footnote a of Table 13).

For **controls** with wiring between a sensor, sensing or actuating element and the rest of the **control** where part of this wiring is, or is intended to be, also part of the fixed installation the manufacturer shall give in the documentation the relevant information for proper installation and the appropriate type of cable or cord required for that part of the fixed installation.

[f] **In-line cord**, **free-standing** and **independently mounted controls**, if fitted with **non-detachable cords** using **type Y attachments** or **type Z attachments**, shall have documentation (D) containing the substance of one of the following statements, whichever is appropriate:

– "The supply cord of this control cannot be replaced; if the cord is damaged, the control should be discarded" (Z)

or

– "The supply cord of this control can be replaced only by the manufacturer or his accredited service agent" (Y).

[g] The method of packaging does not have to be declared.

[h] For **in-line cord**, **free-standing** and **independently mounted controls**, this information shall be provided by method C.

[i] α_1 = minimum rising rate

β_1 = minimum falling rate

The rate of change (α_1 and $\beta_{1)}$ of the **activating quantity** are those applicable to **normal use**.

α_2 = maximum rising rate (for **type 2 actions** only)

β_2 = maximum falling rate (for **type 2 actions** only)

For test purposes, α_1 and β_1 shall be as declared but not lower than the limit(s) indicated in the appropriate Part 2 standards for **type 1 actions** and/or **type 2 actions**. The values α_2 and β_2 are for test purposes only, and may alternatively be declared as a maximum cycling rate. The rates of change for the purpose of this standard shall be expressed in the units as shown in the following table*:

Activating quantity	Unit for rate of change
Pressure	Pa/s
Temperature	K/h
Position	mm/s
Illumination	lux/s
Velocity	mm/s^2
Liquid level	mm/s
Current	A/s
Humidity	%/s
Air flow	m^3/s^2

* When using other activating quantities, the units shall be expressed in SI-units.

[j] The manufacturer may declare a time before which, or a specific value of **activating quantity** above which, manual reset shall not occur.

[k] Void

[l] Void

[m] to [t] See Annex H.

[C] Za These declarations are intended to cover normal use. [C]

7.3 Class II symbol

7.3.1 The symbol for class II construction shall be used only for **controls** classified according to 6.8.3.4.

7.3.2 The dimension of the symbol for class II construction shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square.

7.3.2.1 The length of the sides of the outer square of the symbol shall be not less than 5 mm, unless the largest dimension of the **control** is 15 mm in length or less, in which case the dimension of the symbol may be reduced but the length of the sides of its outer square shall be not less than 3 mm.

7.3.2.2 **Controls** providing protection against electric shock as required for class II but that include terminals for earthing continuity for functional purposes shall not be marked with the symbol for class II construction, IEC 60417-5172 (2003-02), but shall be regarded as **class I controls**.

7.4 Additional requirements for marking

7.4.1 Required marking on a **control** shall preferably be on the main body of the **control** but may be placed on non-**detachable parts**.

Required markings shall be legible and durable.

Compliance is checked by inspection and by the tests of Annex A.

7.4.2 Terminals of **controls** intended for the connection of supply conductors shall be indicated by an arrow pointing towards the terminal, unless the method of connection to the supply mains is of no importance or is self-evident.

Compliance is checked by inspection.

7.4.3 Terminals intended exclusively for a neutral **external conductor** shall be indicated by the letter "N".

NOTE [C] See Annex ZB. [C]

7.4.3.1 Earthing terminals for external earthing conductors or earthing continuity, and terminals for earthing for functional purposes (as opposed to purposes of protection against electric shock) shall be indicated

– for protective earth, by the earth symbol for protective earth, IEC 60417-5019 (2006-08);

– for functional earth, by the earth symbol for functional earth, IEC 60417-5018 (2011-07).

7.4.3.2 All other terminals shall be suitably identified, their purpose self-evident or the **control** circuitry visually apparent. The arrow, the letter "N" or the earth symbol shall not be used except as indicated above.

Compliance is checked by inspection.

[C] NOTE See Annex ZB. [C]

7.4.4 **Controls** intended to be set by the **user** or by the **equipment manufacturer** during installation shall be provided with an indication of the direction to increase or decrease the **response value**.

NOTE An indication of "+" or "–" is sufficient.

Controls intended to be set by the **equipment manufacturer** or the **installer** shall be accompanied by documentation (D) indicating the proper method for securing the **setting**.

7.4.5 Parts destroyed during the normal **operation** of the **control** and which have to be replaced shall be marked so as to enable them to be identified from a catalogue or the like, even after they have operated, unless they are intended to be replaced only during **manufacturer servicing**.

7.4.6 **Controls** intended to be connected only to **SELV systems** shall be marked with the graphic symbol IEC 60417-5180 (2003-02). This requirement does not apply where the means of connection to the supply is so shaped that it can only mate with a particularly designed **SELV** or PELV arrangement.

Controls providing protection against electric shock as required for **class III controls** but that carry terminals for earthing continuity for functional purposes shall not be marked with the symbol for class III construction, IEC 60417-5180 (2003-02).

7.4.7 If an equipment is provided with a replaceable battery, and if replacement by an incorrect type could result in an explosion (for example, with some lithium batteries), the following applies:

– if the battery is intended to be replaced by the **user**, there shall be a marking close to the battery or a statement in both the instructions for use and the service instructions;
– if the battery is not intended to be replaced by the **user**, there shall be a marking close to the battery or a statement in the service instructions.

This marking or statement shall include the following or similar text:

CAUTION
RISK OF EXPLOSION IF BATTERY IS REPLACED BY AN INCORRECT TYPE
DISPOSE OF USED BATTERIES ACCORDING TO THE INSTRUCTIONS

7.4.8 The battery compartment of **controls** incorporating batteries that are intended to be replaced by the **user** shall be marked with the battery voltage and the polarity of the terminals.

If colours are used, the positive terminal is to be identified in red and the negative terminal in black.

Colour is not to be used as the only indication of polarity.

7.4.9 The instructions for **controls** incorporating batteries that are intended to be replaced by the **user** shall include the following:

– the type reference of the battery;
– the orientation of the battery with regard to polarity;
– the method of replacing batteries;
– warning against using incorrect type batteries;

– how to deal with leaking batteries.

The instructions for **controls** incorporating a battery that contains materials which are hazardous to the environment shall give details on how to remove the battery and shall state that:

– the battery must be removed from the **control** before it is scrapped;
– the **control** must be disconnected from the supply mains when removing the battery;
– the battery is to be disposed of safely.

7.4.10 See Annex V.

8 Protection against electric shock

8.1 General requirements

8.1.1 **Controls** shall be so constructed that there is adequate protection against accidental contact with **live parts**, in any unfavourable position which may occur in **normal use**, and after any accessible **detachable parts**, other than lamps located behind a detachable **cover** have been removed. However, during the insertion and removal of lamps, protection against accidental contact with **live parts** of the lamp cap shall be ensured.

Unless otherwise specified, **SELV**-circuits or PELV-circuits supplied at a voltage not exceeding 24 V are not considered to be **hazardous live parts**.

If **SELV**- or PELV-circuits supplied at higher than 24 V, 〈A1〉 or higher than declared according to requirement 87 of Table 1, 〈A1〉 are accessible, the current between the **accessible part**(**s**) and either pole of the supply source of the **SELV**/PELV circuits shall comply with H.8.1.10.1.

8.1.1.1 The value of the voltage of **SELV**/PELV circuits considered to be not hazardous may be specified at a different value

– if the **control** is intended only to be used in an application governed by another product standard where the limit value of the voltage for accessible bare conductors of **SELV**/PELV is different

and

– if the manufacturer declares the application, product standard governing the application and level of voltage for accessible **SELV**/PELV circuits considered to be non-hazardous by the application standard (Table 1, requirement 86).

〈C〉 *Text deleted* 〈C〉

8.1.2 For **class II controls** and **controls** for class II equipment, this requirement applies also with regard to accidental contact with metal parts separated from **hazardous live parts** by **basic insulation** only.

8.1.3 The insulating properties of lacquer, enamel, paper, cotton, oxide film on metal parts, beads and sealing compounds shall not be relied upon to give the required protection against accidental contact with **hazardous live parts**.

NOTE Sealing compounds of the self-hardening types can be touched.

8.1.4 For those **class II controls** and **controls** for class II equipment which are connected in **normal use** to the gas supply mains or to the water supply mains, any metal parts

conductively connected to the gas pipes or in electrical contact with the water system shall be separated from **hazardous live parts** by **double insulation** or **reinforced insulation**.

8.1.5 Those **class II controls** and **controls** for class II equipment which are intended to be permanently connected to **fixed wiring** shall be so designed that the required degree of protection against electric shock is not impaired by the installation of the **control**.

NOTE The protection against electric shock of **class II independently mounted controls** can be affected, for example, by the installation of metal conduits or of cables provided with a metal sheath.

8.1.6 *For **integrated** and **incorporated controls**, the tests of 8.1.9 to 8.1.9.5 inclusive is only applied to those parts of the **control** which are accessible when it is mounted in any position in accordance with the manufacturer's declarations and after removal of **detachable parts**.*

8.1.7 *For **in-line cord** and **free-standing controls**, the tests of 8.1.9 to 8.1.9.5 inclusive, are made when the **control** is fitted with flexible cords either of the smallest, or of the largest nominal cross-sectional area used in 10.1.4, whichever is more unfavourable. **Detachable parts** are removed, and hinged **covers** which can be opened without the use of a **tool** are opened.*

8.1.8 *For **independently mounted controls**, the test is made when the **control** is mounted as in **normal use**, fitted with cable of the smallest or of the largest nominal cross-sectional area used in 10.1.4, whichever is more unfavourable, or with a rigid, pliable or flexible conduit. **Detachable parts** are removed, and hinged **covers** which can be opened without the use of a **tool** are opened.*

8.1.9 *Compliance with 8.1.1 to 8.1.8 inclusive is checked by inspection and by the following tests:*

The standard test finger shown in Figure 2 is applied without force in every possible position. Apertures preventing the entry of the finger are further tested by means of a straight unjointed test finger of the same dimensions which is applied with a force of 20 N; if this finger enters, the test with the finger shown in Figure 2 is repeated, the finger being pushed through the aperture if necessary. If the unjointed test finger does not enter, the force applied is increased to 30 N. If then the guard is so displaced or the aperture so distorted that the test finger shown in Figure 2 can be inserted without force, the test with the latter finger is repeated. An electrical contact indicator is used to show contact.

NOTE A lamp can be used for the indication of contact, with the voltage not less than 40 V.

8.1.9.1 *The standard test finger shall be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger in the same direction only.*

8.1.9.2 *In addition, openings in insulating material and in unearthed metal shall be tested by applying the test pin shown in Figure 1 without force in every possible position.*

8.1.9.3 *It shall not be possible, with either the standard test finger or the test pin, to touch **hazardous live parts**.*

8.1.9.4 *For **controls** which have any parts of **double insulation** construction, it shall not be possible to touch metal parts with the standard test finger which are only separated from **hazardous live parts** by **basic insulation**.*

8.1.9.5 *If there is an instruction to remove a part during **normal use** or **user maintenance** and if there is no warning on the part which indicates: "Disconnect from supply before removing", that part is regarded as a **detachable part** even if a **tool** has to be used for its removal. If there is such a warning on the part, it is permissible, after removal, to touch parts separated from **hazardous live parts** by **basic insulation**.*

8.1.10 See Annex H.

8.1.11 Between class III circuits and circuits connected to the mains or earth, insulation external to the **safety isolating transformer** shall comply with all requirements for class II insulation.

NOTE Where a circuit is not specifically required to be class III, class II requirements are not applicable between the class III circuit and earth.

8.1.12 A **live part** shall be considered to be hazardous if it exceeds the values specified in 8.1.1 and it is not separated from the source by **protective impedance** complying with H.8.1.10 and is not a PEN conductor or a part of the **equipotential bonding system**.

8.1.13 **Controls** having battery compartments that can be opened without the aid of a **tool**, or that according to the instructions for use may be replaced by the **user** need only have **basic insulation** between **live parts** and the inner surface of the battery compartment. If the **control** can be energized without the batteries, **double insulation** or **reinforced insulation** is required.

NOTE If a part has to be removed in order to discard the battery before scrapping the **control**, this part is not considered to be detachable even if the instructions state that it is to be removed.

8.2 Actuating members and actuating means

8.2.1 An **actuating member** shall not be live.

8.2.2 An **actuating means** shall not be live, unless either it is provided with an insulated **actuating member** which is adequately fixed or the **actuating means** is not accessible when the **actuating member** is removed.

Compliance with 8.2.1 and 8.2.2 is checked by inspection and by the tests of 8.1.

NOTE An insulated **actuating member** is considered to be adequately fixed if it can be removed only by breaking, cutting, or after being seriously damaged.

8.2.3 For **controls** other than class III or **controls** for equipment other than those of class III, **actuating members** and handles held in **normal use** shall be either of insulating material, or adequately covered by insulating material; or, if of metal, their **accessible parts** shall be separated from their **actuating means**, or fixings by **supplementary insulation**, if such would be likely to become live in the event of an insulation **fault**.

For **controls** for connection to **fixed wiring**, or for **controls** for stationary equipment, this requirement does not apply provided that such parts are either:

– reliably connected to an earthing terminal or earthing contact; or

– shielded from **hazardous live parts** by earthed metal.

Compliance is checked by inspection.

NOTE Parts separated from **hazardous live parts** by **double insulation** or **reinforced insulation** are not regarded as likely to become live in the event of an insulation **fault**.

8.3 Capacitors

8.3.1 For class II **in-line cord controls** and **independently mounted controls**, capacitors shall not be connected to accessible metal parts. For **controls** for class II equipment, capacitors shall not be connected to metal likely to be connected to accessible metal when the **control** is mounted in accordance with the manufacturer's declarations. Metal casings of capacitors shall be separated by **supplementary insulation** from accessible metal parts, and from other metal parts likely to be connected to accessible metal, when the **control** is mounted in accordance with the manufacturer's declarations.

*Compliance is checked by inspection and by the requirements for **supplementary insulation** in Clauses 13 and 20.*

8.3.2 **Controls** intended to be connected to the supply by means of a plug shall be so designed that in **normal use**, there is no **risk** of electric shock from charged capacitors when touching the pins of the plug.

Compliance is checked by the test of 8.3.2.1 to 8.3.2.4 inclusive, which is made 10 times.

8.3.2.1 *The **control** is supplied at rated voltage or at the upper limit of the rated voltage range.*

8.3.2.2 *The **actuating member**, if any, is then moved to the "OFF" position if one exists and the **control** is disconnected from the supply by removing the plug from the socket-outlet.*

8.3.2.3 *One second after disconnection, the voltage between the pins of the plug is measured.*

8.3.2.4 *The voltage shall not exceed 34 V peak. The test is only performed if the capacitor exceeds 0,1 μF.*

8.4 Covers and uninsulated live or hazardous parts

Controls provided with a **cover** or **cover plate** of non-metallic material shall be so designed that the **cover** fixing screws are not accessible, unless they are either earthed or separated from **hazardous live parts** by **double insulation** or **reinforced insulation** or not accessible after mounting in the equipment.

Compliance is checked by inspection.

〖C〗 *Text deleted* 〖C〗

8.5 See Annex V.

9 Provision for protective earthing

9.1 General requirements

9.1.1 Accessible metal parts, other than **actuating members**, of **in-line cord**, **free-standing** and **independently mounted controls** of class 0I and class I which may become live in the event of an insulation **fault**, shall be permanently and reliably connected to an earthing terminal or **termination** within the **control**, or to the earthing contact of an equipment inlet. 〖C〗 See Annex ZB. 〖C〗

NOTE 1 The phrase "permanently and reliably connected to an earthing terminal" is synonymous with the term "bonded".

NOTE 2 Parts separated from **live parts** by **double insulation** or **reinforced insulation** and parts screened from **live parts** by metal parts connected to an earthing terminal, earthing **termination** or earthing contact, are not regarded as likely to become live in the event of an insulation **fault**.

NOTE 3 Requirements for **actuating members** are specified in 8.2.3.

9.1.2 Accessible metal parts, other than **actuating members**, of integrated and **incorporated controls** for class 0I and class I equipment which may become live in the event of an insulation **fault** shall have provision for earthing. 〖C〗 See Annex ZB. 〖C〗

NOTE 1 **Integrated controls** and **incorporated controls** may be connected to earth through their fixing means, provided that provision is made for clean metallic surfaces. This also applies, for example, to **controls** with metallic **sensing elements** which are connected reliably to the metal parts of the equipment if the manufacturer has declared this to be a method of earthing.

NOTE 2 Parts separated from **live parts** by **double insulation** or **reinforced insulation**, and parts screened from **live parts** by metal parts connected to an earthing terminal, earthing **termination** or earthing contact, are not regarded as likely to become live in the event of an insulation **fault**.

NOTE 3 Requirements for **actuating members** are specified in 8.2.3.

9.1.3 Earthing terminals, earthing **terminations** and earthing contacts shall not be electrically connected to any neutral terminal.

Compliance with 9.1.1 to 9.1.3 inclusive is checked by inspection.

9.2 Class II and class III controls

Class II and class III controls shall have no provision for protective earthing.

Compliance is checked by inspection.

9.3 Adequacy of earth connections

9.3.1 General requirements

The connection between an earthing terminal, earthing **termination** or earthing contact, and parts required to be connected thereto, shall be of low resistance.

Compliance is checked by the following test:

– *A current of 1,5 times the rated current, but not less than 25 A, and derived from an a.c. source with a no-load voltage not exceeding 12 V, is passed between the earthing terminal, earthing **termination** or earthing contact, and each of the parts, in turn.*

– *The voltage drop between the earthing terminal, earthing **termination** or earthing contact and the part is measured, and the resistance calculated from the current and this voltage drop. In no case shall the resistance exceed 0,1 Ω. The test is continued until steady conditions have been established.*

NOTE 1 Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

NOTE 2 The resistance of any **external conductor** or **internal conductor** is not included in the resistance measurement, but the resistance of any **integrated conductor** is included.

9.3.2 Fixed wiring and methods X and M

Earthing terminals for the connection of **fixed wiring** or for **non-detachable cords** using methods X and M shall comply with the requirements of 10.1.

〖C〗 *Text deleted* 〖C〗

9.3.3 External conductors

Earthing connections for **external conductors** shall not be made using **screwless terminals**, however for **type Y attachment** and **type Z attachment**, screwless-type clamping units complying with IEC 60998-2-2 or 60998-2-3 or screwless-type clamping units according to IEC 60999-1 are allowed.

9.3.4 Size of accessible earthing terminals

Earthing terminals which are accessible in **normal use** shall allow the connection of conductors having nominal cross-sectional areas of 2,5 mm^2 to 6 mm^2 inclusive and it shall not be possible to loosen them without the aid of a **tool**.

〖C〗 *Text deleted* 〖C〗

9.3.5 Size of non-accessible earthing terminals

Earthing terminals which are not accessible in **normal use** for **external conductors** shall be of a size equal to or larger than that required for the corresponding current-carrying terminal.

9.3.6 Locking of earthing terminals

Clamping means of earthing terminals for **external conductors** shall be adequately locked against accidental loosening.

Compliance with 9.3.2 to 9.3.6 inclusive is checked by inspection, by manual test and by the appropriate tests of 10.1.

NOTE In general, the designs commonly used for current-carrying terminals provide sufficient resilience to comply with the requirement for adequate locking against accidental loosening, provided that there is no excessive vibration or temperature cycling. If the terminal is subjected to excessive vibration or temperature cycling, special provision such as the use of an adequately resilient part, for example, a pressure plate which is not likely to be removed inadvertently, can be necessary when **pillar terminals** are used.

9.4 Corrosion resistance

All parts of an earthing terminal shall be resistant to corrosion resulting from contact between those parts and the copper of the earthing conductor or any other metal that is in contact with those parts.

9.4.1 Materials

The body of an earthing terminal shall be of brass, or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure. Then any screws or nuts shall be of brass, plated steel or other metal complying with Clause 22, or other metal no less resistant to corrosion.

9.4.2 Frames or enclosures of aluminium

If the body of an earthing terminal is a part of a frame or enclosure of aluminium or aluminium alloy, precautions shall be taken to avoid the **risk** of corrosion resulting from contact between copper and aluminium or its alloys.

Compliance with 9.4, 9.4.1, and 9.4.2 is checked by inspection, and in cases of doubt by an analysis of the materials and their coatings.

NOTE Corrosion resistance can be achieved by plating or similar process.

9.5 Other requirements

9.5.1 Detachable parts

If a **detachable part** of a **control** has an earth connection, this connection shall be made before any current-carrying connections are established when placing the part in position, and any current-carrying connections shall be separated before the earth connection is broken when removing the part.

Compliance is checked by inspection.

〚C〛 *Text deleted* 〚C〛

10 Terminals and terminations

See also Clause 20, third paragraph.

10.1 Terminals and terminations for external copper conductors

10.1.1 Terminals for **fixed wiring** and for **non-detachable cords** using **type X attachment** and **type M attachment**, except as specified in 10.1.3, shall be such that connection is made by means of screws, nuts or equally effective devices or methods, but without requiring a **special purpose tool** for connection or disconnection.

10.1.1.1 Terminals or **terminations** for **non-detachable cords** using **type Y attachment** and **type Z attachment** shall satisfy the appropriate requirements for terminals and **terminations** for **internal conductors** and may require the use of **special purpose tools** for connection or disconnection.

Compliance with 10.1.1 and 10.1.1.1 is checked by inspection and test.

NOTE 1 Screw type terminals in accordance with IEC 60998-2-1, **screwless terminals** in accordance with IEC 60998-2-2 or IEC 60998-2-3 and clamping units in accordance with IEC 60999-1 are considered to be effective devices.

NOTE 2 Flat push-on terminals are deemed to require a **special purpose tool** for effecting the crimp.

10.1.2 Screws and nuts which clamp **external conductors** shall have a metric ISO thread or a thread of equivalent effectiveness. They shall not serve to fix any other component, except that they may also clamp **internal conductors** if these are so arranged that they are unlikely to be displaced when fitting the **external conductors**.

Compliance is checked by inspection.

NOTE 1 Provisionally, SI, BA and Unified threads are deemed to be of equal effectiveness to metric ISO thread.

NOTE 2 A test for equivalent effectiveness is under consideration. Pending agreement to such a test, all torque values for threads other than ISO, SI, BA and Unified are increased by 20 %.

10.1.3 Soldered, welded, crimped or similar terminations

Soldered, welded, crimped or similar **terminations** shall not be used for the connection of **non-detachable cords** using **type X attachment** and **type M attachment** unless such is permitted by the appropriate equipment standard. When such **terminations** are used for **external conductors**, they shall also comply with the requirements of 10.2.2 and 10.2.3.

Compliance is checked by inspection.

NOTE In general, the standards for equipment restrict the use of such connections.

10.1.4 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall allow at least the connection of conductors having nominal cross-sectional areas as shown in Table 3.

Compliance is checked by inspection, by measurement and by fitting conductors of the smallest and largest cross-sectional areas specified or declared.

Table 3 (10.1.4 of edition 3) – Minimum cross-sectional area of conductors

Current carried by terminal [a] A	**Nominal cross-sectional area** mm^2	
	Flexible cord conductor	**Fixed wiring conductors**
Up to 6 and including [c]	0,5 to 1	1 to 1,5
Over 6 up to and including 10	0,75 to 1,5	1 to 2,5
Over 10 up to and including 16	1 to 2,5	1,5 to 4
Over 16 up to and including 25	1,5 to 4	2,5 to 6
Over 25 up to and including 32	2,5 to 6	4 to 10
Over 32 up to and including 40	4 to 10	6 to 16
Over 40 up to and including 63	6 to 16	10 to 25

[a] Requirements for applications greater than 63 A are under consideration.

[b] 〚C〛 Void 〚C〛

[c] The nominal cross-sectional areas specified do not apply to terminals in **SELV**-circuits or PELV-circuits carrying a current not exceeding 3 A.

10.1.4.1 If a terminal is designed to accommodate a wider range of **fixed wiring** or flexible cord conductor sizes than those indicated in columns 2 and 3 of Table 3, then this shall be declared.

〚C〛 *Text deleted* 〚C〛

10.1.5 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, **internal conductors** are not subjected to stress, and **creepage distances** and **clearances** are not reduced below the values specified in Clause 20.

Compliance is checked by inspection and by measurement after fastening and loosening a conductor of the largest cross-sectional area used in 10.1.4 10 times, the conductor being moved each time it is loosened. For threaded parts, the full torque applied is either that shown in Table 20, or the torque specified in the relevant figure (see Figures 10 to 13), whichever is greater.

During the test, terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers, stirrups or other parts, that will impair the further use of the terminal.

NOTE 1 This requirement does not imply that the terminal must be so designed that rotation or displacement is prevented, provided that its movement does not bring about non-compliance with the other requirements of this standard.

NOTE 2 Terminals can be prevented from working loose by fixing with two screws, by fixing with one screw in a recess or by other suitable means.

NOTE 3 Covering with sealing compound, or with resins, is only considered to be a sufficient means for preventing a terminal from working loose if:

– the seal is not subject to mechanical strain as a result of connection or disconnection of the conductor or use of the equipment; and

– the effectiveness of the sealing compound is not impaired by the temperature which is attained by the terminal under the most unfavourable conditions required by this standard.

10.1.6 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without undue damage to the conductor, except that for **screwless terminals** intended for circuits carrying a current not exceeding 2 A, one of the surfaces may be of non-metallic material.

Compliance is checked by inspection of the terminal and of the conductors after the test of 10.1.5.

NOTE Conductors are considered to be unduly damaged if they show sharp or deep indentations.

10.1.7 Terminals for **fixed wiring** and **non-detachable cords** using **type X attachment** shall not require special preparation of the conductor in order to effect correct connection.

10.1.7.1 Terminals for **type X attachment** may also have alternative means of connection if at least one of the means conforms to this requirement, even if the original factory-made connection uses another means. In this case, the original factory-made connection shall comply with the requirements for terminals and **terminations** for **internal conductors**.

Compliance is checked by inspection.

NOTE The term "special preparation of the conductor" covers soldering of the strands, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate its end.

10.1.8 Terminals for **fixed wiring** and **non-detachable cords** using **type X attachment** or **type M attachment** shall be so designed or placed that neither the conductor nor a wire of a stranded conductor can slip out while any clamping screws or nuts are being tightened, or while any equally effective device is being operated.

10.1.8.1 *Compliance is checked by the following test.*

10.1.8.2 *Terminals are fitted with conductors according to the use of the terminal, in accordance with Table 4. The wires of **fixed wiring** conductors are straightened before inserting into the terminal.*

10.1.8.3 *The wires of flexible cables and cords are twisted so that there is an even twist of one complete turn in 20 mm. The conductor is inserted into the terminal for the minimum distance prescribed, or where no distance is prescribed, until it just projects from the far side of the terminal. The conductor is inserted into the terminal in the position most likely to assist a wire to escape and then the screw is tightened with a torque equal to two-thirds of the torque specified in Table 20.*

10.1.8.4 *For flexible cords, the test is repeated using a new conductor which is twisted as before, but in the opposite direction. After the test, no wire of the conductor shall have escaped into the gap between the clamping means and the retaining device.*

Table 4 (10.1.8 of edition 3) – Terminal conductors

Current carried by terminal [a] A		**Conductor to be fitted (number of wires and nominal diameter of each wire in millimetres)**	
Flexible cord conductors	**Fixed wiring conductors**	**For flexible cord conductors**	**For fixed wiring conductors**
0 to 6	–	32 × 0,20	–
6 to 10	0 to 6	40 × 0,25	7 × 0,52
10 to 16	6 to 10	50 × 0,25	7 × 0,67
16 to 25	10 to 16	56 × 0,30	7 × 0,85
25 to 32	16 to 25	84 × 0,30	7 × 1,04
–	25 to 32	94 × 0,30	7 × 1,35
32 to 40	32 to 40	80 × 0,40	7 × 1,70
40 to 63	40 to 63	126 × 0,40	7 × 2,14
[a] Requirements for applications greater than 63 A are under consideration.			

10.1.9 Terminals shall be so designed that they clamp the conductor reliably.

Compliance is checked by the following test.

10.1.9.1 *The terminals are fitted with conductors of the smallest and largest nominal cross-sectional areas used in 10.1.4, fixed or flexible, whichever is appropriate, or the more unfavourable and the terminal screws are tightened, the torque applied being equal to two-thirds of the torque specified in Table 20. Each conductor is subjected to a pull of the value shown in Table 5. The pull is applied without jerks for 1 min, in the direction of the axis of the conductor space.*

10.1.9.2 *This pull test is normally applied directly to the conductor adjacent to where it enters the terminal. If, however, an additional crimping or clamping device holding the conductor or the insulation around the conductor exists not more than 30 mm from the entry point for the conductor into the terminal and measured along the length of the conductor, this test should apply to the crimping or clamping device, and not to the actual terminal.*

10.1.9.3 During the test the conductor shall not move appreciably in the terminal.

Table 5 (10.1.9 of edition 3) – Conductor pull test values

Current carried by terminal [a] A	**Pull** N	
	Terminals for flexible cord conductors	**Terminals for fixed wiring conductors**
Up to and including 3	20 [b]	20 [b]
Over 3 up to and including 6	30	30
Over 6 up to and including 10	30	50
Over 10 up to and including 16	50	50
Over 16 up to and including 25	50	60
Over 25 up to and including 32	60	80
Over 32 up to and including 40	90	90
Over 40 up to and including 63	100	100

[a] Requirements for applications greater than 63 A are under consideration.

[b] Applicable only to **SELV**-circuits or PELV-circuits, and other applications where particular conductors are not specified.

10.1.10 Terminals shall be so designed that they do not attain excessive temperature in **normal use**, so as to damage the material of the supporting insulation, or the insulating covering of the clamped conductors.

Compliance is checked during the heating tests of Clause 14.

10.1.11 Terminals shall be so located that each core contained within any **fixed wiring** sheath or flexible cord sheath can be terminated in reasonable proximity to the other cores within the same sheath, unless there is a good technical reason for the contrary.

Compliance is checked by inspection.

10.1.12 Terminals for **non-detachable cords** using **type X attachment** or **type M attachment** shall be so located or shielded, that should a wire escape when the conductors are fitted, there is no **risk** of accidental contact between **live parts** and accessible metal parts, and for **class II controls** and **controls** for class II equipment, between **live parts** and metal parts separated from accessible metal parts by **supplementary insulation** only. Furthermore, there shall be no **risk** of short-circuiting a declared action providing a **full disconnection** or a **micro-disconnection**.

Compliance is checked by inspection and by the following test:

– *An 8 mm length of insulation is removed from the end of a stranded conductor having a nominal cross-sectional area equal to the minimum size used during the test of 10.1.4. One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal. The free wire is bent, without tearing the insulation back, in every direction, but without making sharp bends around barriers.*

– *The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible or is connected to an accessible metal part, or for **class II controls** and **controls** of class II equipment, any metal part which is separated from accessible metal parts by **supplementary insulation** only.*

– *The free wire of a conductor connected to an earthing terminal shall not touch any **live part**.*

– *The free wire of a conductor connected to a live terminal shall not become accessible, nor shall it short-circuit a declared action providing a **full disconnection** or a **micro-disconnection**.*

10.1.13 Terminals shall be so designed that circuit continuity is not maintained by pressure transmitted through insulating material other than ceramic, or other insulating material with characteristics no less suitable, unless there is sufficient resilience in the appropriate metal parts to compensate for any shrinkage or distortion.

Compliance is checked by initial inspection and by further examination of the terminals when the samples have completed the test of Clause 17.

NOTE The suitability of the material is considered in respect to the stability of the dimensions within the temperature range applicable to the **control**.

10.1.14 Screws and threaded parts of terminals shall be of metal.

Compliance is checked by inspection.

〚C〛 *Text deleted* 〚C〛

10.1.15 **Terminals** of the **pillar type** and the **mantle type** shall be so designed as to allow an adequate length of conductor to be introduced into, and pass beyond the edge of the screw, to ensure that the conductor does not fall out.

*Compliance is checked for **pillar terminals** by measurement of dimension "g" in Figure 11 and for **mantle terminals** by the minimum distance specified in Figure 12.*

NOTE In the U.S.A. and Canada, Subclauses 10.1.16 and 10.1.16.1 apply:

〚C〛 *Text deleted* 〚C〛

10.2 Terminals and terminations for internal conductors

10.2.1 Connection of conductors

Terminals and **terminations** shall allow the connection of conductors having nominal cross-sectional areas as shown in Table 6.

〚C〛A terminal or termination is not required if a conductor is permanently connected to the control by the control manufacturer. 〚C〛

Table 6 (10.2.1 of edition 3) – Nominal cross-sectional areas of conductors

Current carried by terminal or terminations [a] A	**Minimum nominal cross-sectional area of conductor** mm^2
Up to and including 3	– [c]
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

[a] Requirements for applications greater than 63 A are under consideration.

[b] Void

[c] No minimum specified, but the manufacturer shall declare the conductor size for test purposes.

NOTE The requirements of 10.2.1 do not apply to terminals which are not intended to accept standard conductors without special preparation, or which, by their design and application, cannot accept standard conductors; or which are deliberately designed to accept conductors of a different size and which are for use only in particular types of equipment. An example is a **thermostat** intended for use within the fabric of an electric blanket.

10.2.2 Suitability for purpose

Terminals and **terminations** shall be suitable for their purpose. **Terminations** for making soldered, crimped and welded connections shall be capable of withstanding the stresses which occur in normal service.

Compliance is checked by inspection.

10.2.3 Soldered terminals

When soldered terminals are used, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided such that **creepage distances** and **clearances** between **live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in Clause 20 should the conductor break away at the soldered joint.

Compliance is checked by inspection.

NOTE In general, "hooking-in" before soldering is considered to be a suitable means for maintaining a conductor in position, provided the hole through which the conductor is passed is not unduly large, and provided that the conductor is not part of a flat-twin tinsel cord.

Other methods of maintaining a conductor in position, such as waisting the sides of a solder tag, are also considered acceptable.

10.2.4 Flat push-on connectors

10.2.4.1 Tabs forming part of a **control** shall comply with the dimensional requirements of Figure 14 or 15.

Compliance is checked by measurement.

Tabs with dimensions other than those shown in Figure 14 or 15 can be used, if the dimensions and shapes are so different as to prevent any possible mismating with a standard **receptacle** (see Figure 16).

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may alternatively be used. The performance requirements of IEC 61210 do not apply.

Tabs allowing the polarized acceptance of **receptacles** can be used (see Figure 16).

10.2.4.2 Tabs forming part of a **control** shall consist of material and plating appropriate to the maximum temperature of the **tabs** as indicated in Table 7. Materials or coatings other than those specified in the table can be used provided their electrical and mechanical characteristics are no less reliable, particularly with regard to resistance to corrosion and mechanical strength.

Table 7 (10.2.4.2 of edition 3) – Material and plating for tabs

Material and plating of tabs	**Maximum temperature of the tab** °C
Bare copper	155
Bare brass	210
Tin plated copper and copper alloys	160
Nickel plated copper and copper alloys	185
Silver plated copper and copper alloys	205
Nickel plated steel	400
Stainless steel	400

Compliance is checked by measuring the temperatures attained during the tests of Clause 14.

NOTE The temperatures specified are those for continuous use. Higher transient temperatures are possible, for example, during temperature overshoot of a temperature **sensing control**.

10.2.4.3 Tabs forming part of a **control** shall have adequate strength to allow the insertion and withdrawal of **receptacles** without damage to the **control** such as to impair compliance with this standard.

Compliance is checked by applying, without jerks, axial forces equal to those shown in Table 8. No significant displacement or damage shall occur.

Table 8 (10.2.4.3 of edition 3) – Axial force values for tab insertion and withdrawal

Tab size (see Figure 16)	**Push** [a] N	**Pull** [a] N
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[a] The values in the table are the maximum allowed for the insertion and the withdrawal of a **receptacle** from a **tab**.

10.2.4.4 Tabs forming part of a **control** shall be adequately spaced to allow the connection of the appropriate **receptacles**.

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may alternatively be used. The performance requirements of IEC 61210 do not apply.

*Compliance is checked by applying an appropriate **receptacle** on each **tab** unless otherwise declared in 7.2. During this application, no strain nor distortion shall occur to any of the **tabs** nor to their adjacent parts, nor shall the **creepage distance** or **clearance** values be reduced below those specified in Clause 20.*

NOTE For **tabs** complying with Figure 14 or 15, the appropriate **receptacle** is shown in Figure 16.

10.3 Terminals and terminations for integrated conductors

There are no specific requirements or tests for terminals or terminations for **integrated conductors** under Clause 10, but the relevant requirements of the other clauses may apply.

11 Constructional requirements

11.1 Materials

11.1.1 Insulating materials – Impregnated

Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation unless impregnated.

Compliance is checked by inspection.

NOTE Insulating material is considered to be impregnated if the interstices between the fibres of the materials are substantially filled with a suitable insulant.

11.1.2 Current-carrying parts

If brass is used for current carrying parts other than threaded parts of terminals, it shall contain at least 50 % copper if the part is cast or made from bar, or at least 58 % if the part is made from rolled sheet.

Compliance is checked by inspection and by analysis of the material.

11.1.3 Non-detachable cords

11.1.3.1 Non-detachable cords of **class I controls** shall have a green/yellow conductor insulation which is connected to the earthing terminal or **termination** of the **control**, or to the earthing contact of any equipment inlet or socket-outlet, if provided.

11.1.3.2 Conductor insulation identified by the colour combination green/yellow shall not be connected to terminals or **terminations** other than earthing terminals or **terminations**.

Compliance with 11.1.3.1 and 11.1.3.2 is checked by inspection.

11.2 Protection against electric shock

11.2.1 Double insulation

When **double insulation** is employed, the design shall be such that the **basic insulation** and the **supplementary insulation** can be tested separately unless satisfaction with regard to the properties of both insulations is provided in another way.

11.2.1.1 If the **basic insulation** and the **supplementary insulation** cannot be tested separately, or if satisfaction with regard to the properties of both insulations cannot be obtained in another way, the insulation is regarded as **reinforced insulation**.

Compliance is checked by inspection and by test.

Text deleted

11.2.2 Infringement of double insulation or reinforced insulation

Class II controls and **controls** for use in class II equipment shall be so designed that **creepage distances** and **clearances** over **supplementary insulation** or **reinforced insulation** cannot, as a result of wear, be reduced below the values specified in Clause 20. They shall be so constructed that if any wire, screw, nut, washer, spring, flat push-on **receptacle** or similar part becomes loose and falls out of position, it cannot in **normal use** become so disposed that **creepage distances** or **clearances** over **supplementary insulation** or **reinforced insulation** are reduced to less than 50 % of the value specified in Clause 20.

Compliance is checked by inspection, by measurement and/or by manual test.

For the purpose of this requirement:

- *it is not to be expected that two independent fixings will become loose at the same time;*
- *parts fixed by screws or nuts provided with a locking washer are regarded as not liable to become loose, provided these screws or nuts are not required to be removed during **user maintenance** or **servicing**;*
- *springs and spring parts that do not become loose or fall out of position during the tests of Clauses 17 and 18 are deemed to comply;*
- *wires connected by soldering are considered to be not adequately fixed unless they are held in place near to the **termination**, independently of the solder;*
- *wires connected to terminals are considered to be not adequately secured unless an additional fixing is provided near to the terminal. This additional fixing, in the case of stranded conductors, shall clamp the insulation and not the conductor;*
- *short rigid wires are regarded as not liable to come away from a terminal if they remain in position when any one terminal screw or nut is loosened.*

11.2.3 Integrated conductors

11.2.3.1 **Integrated conductors** shall be so rigid, so fixed or so insulated that in **normal use creepage distances** and **clearances** cannot be reduced below the values specified in Clause 20.

11.2.3.2 Insulation, if any, shall be such that it cannot be damaged during mounting or in **normal use**.

Compliance with 11.2.3.1 and 11.2.3.2 is checked by inspection, by measurement and by manual test.

NOTE If the insulation on a conductor is not at least electrically equivalent to that of cables and flexible cords complying with the appropriate IEC standard, or alternatively does not comply with the electric strength test made between the conductor and metal foil wrapped around the insulation under the conditions specified in Clause 13, the conductor is considered to be a bare conductor.

11.2.4 Flexible cord sheaths

Inside a **control**, the sheath (jacket) of a flexible cable or cord shall be used as **supplementary insulation** only where it is not subject to undue mechanical or thermal

stresses, and if its insulating properties are not less than those specified in IEC 60227-1 or IEC 60245-1.

Compliance is checked by inspection, and, if necessary, by testing the sheaths of the flexible cords according to IEC 60227-1 or IEC 60245-1.

11.2.5 Protective impedance

See Annex H.

11.2.6 Protection against electric shock by use of SELV or PELV

See Annex T.

11.2.7 Connections between internal and external SELV/PELV circuits

Adequate measures shall be provided to prevent the interconnection of an integrated **SELV** circuit to an external PELV circuit and vice versa.

The supply of a **class III control** from an external **SELV** source by means of a separable connection shall only be possible by means of a dedicated plug and socket system which cannot be fitted or interconnected with other connecting systems.

Compliance is checked by inspection.

〈A1〉11.2.8 Overcurrent protection

Controls shall be capable of carrying the currents likely to flow in abnormal conditions for such periods of time as are determined by the characteristics of the protective device if declared in requirement 96 of Table 1.

Compliance is checked by the test of 27.5.〈A1〉

11.3 Actuation and operation

11.3.1 Full disconnection

Controls with positions declared as **full disconnection** shall be so designed that in the declared positions there is contact separation in all supply poles other than earth, at least equal to the relevant values specified in Clause 20. The contact separation may be obtained by **automatic action** or by **manual action**, but any subsequent **automatic action** shall not cause any contact separation to be reduced below the specified minimum.

If the disconnection is also declared to provide **all-pole disconnection**, the contact **operation** in each supply pole shall be substantially together.

Compliance is checked by inspection and by the tests of Clauses 13 and 20, where necessary.

11.3.2 Micro-disconnection

Controls with positions declared as **micro-disconnection** shall be so designed that in the declared positions there is contact separation in at least one supply pole to meet the electric strength requirements of Clause 13 but no **clearance** dimension is specified. The contact separation may be obtained by **automatic action** or by **manual action**, but any subsequent change of **activating quantity** between the limits declared in Table 1, requirement 36, 〈C〉*Text deleted*〈C〉 at any **switch head** temperature between the limits declared

in Table 1, requirement 22, shall not cause an **operation** which would reduce the contact separation such that the requirements of Clause 13 are no longer met.

Compliance is checked by inspection and, where necessary, by the tests of Clause 13 carried out at the temperature limits declared.

11.3.3 Reset buttons

Reset buttons of **controls** shall be so located or protected that they are not likely to be accidentally reset.

Compliance is checked by inspection.

NOTE 1 This requirement precludes, for example, reset buttons mounted in such a position that they can be reset by pushing the **control** against a wall, or by pushing a piece of furniture against the **control**.

NOTE 2 This requirement does not apply to manual reset **controls** with **trip-free** actions.

11.3.4 Setting by the manufacturer

Parts used for the **setting** of **controls** by the manufacturer shall be secured to prevent accidental shifting after **setting**.

Compliance is checked by inspection.

11.3.5 Contacts – General

11.3.5.1 Contacts with a d.c. rating greater than 0,1 A, which can be operated by **actuation**, shall be so designed that the speeds of approach and separation of the contact surfaces are independent of the speed of **actuation**.

Compliance is checked by inspection.

NOTE This requirement does not apply to contacts excluded by 11.3.7.

11.3.5.2 **Systems** of **class C control functions** shall include at least two switching elements to directly de-energize the safety relevant terminals.

NOTE A single relay operating two independent contacts is considered to be only one switching element.

11.3.5.2.1 Measures to prevent common cause errors

Measures shall be taken to protect against **failure** of two (or more) switching elements, due to a common cause, by an external short circuit that would prevent the **control** from performing a **safety shut-down**.

Acceptable methods are, for example,

– overcurrent protection device,
– current limitation or
– internal **fault** detecting means.

The suitability of measures to maintain the capability to interrupt the energization of the safety related output terminals by means of at least one switching element or the interruption of an overcurrent protection device shall be verified by the following test.

*The safety related output terminals of the **control** are connected to a switch that is intended to switch the short-circuit current. With this switch opened, the **control** is connected as described in H.27.1.1.2 with the outputs energized to simulate normal **operation** (contacts of the internal switching elements closed).*

The test equipment shall have the following characteristics:

*a) when overcurrent protection devices are used as the protective measure, the power supply to the **control** shall have the capability of supplying a short-circuit current of at least 500 A.*

*b) when current limitation techniques are used as the protective measure (for example, transformer) the power supply to the **control** shall not limit the declared (Table 1, requirement 95) short-circuit current.*

11.3.5.2.1.1 *A short-circuit is applied between the safety related output terminals of the **control** by closing the switch.*

The test is operated for 1 h or if there is no current flow through the switch.

*If an overcurrent protection device is replaceable and has operated during the test, it shall be replaced and the test is repeated a further two times by attempting to restart the **control** keeping the switch closed.*

The test is repeated using either the same or a separate sample with the switch maintained in the closed position prior to the first start-up sequence.

11.3.5.2.1.2 *If an internal **fault** detecting function of the **control** either opens the switching elements or initiates a **safety shut-down**, the test is repeated two times by attempting to restart the **control** while maintaining the external short circuit.*

Compliance is checked in accordance with H.27.1.1.3 and Clause 15.

*After the test, at least one switching element of the **control** shall be able to de-energize the safety related output terminals, or a non-replaceable overcurrent protection device has permanently interrupted the supply to the safety related output terminals.*

11.3.6 Contacts for full disconnection and micro-disconnection

Contacts for **full disconnection** and contacts for **micro-disconnection**, having either a d.c. rating not greater than 0,1 A, or an a.c. rating, and which can be operated by **actuation**, shall be so designed that they can come to rest only in a closed position or in an open position.

*Compliance is checked by inspection, and for a closed position by the temperature requirements of Clause 14, and for open position by the requirements of Clause 13, as specified for **micro-disconnection**. However, where an **intermediate position** of the **actuating member** occurs adjacent to a **located position** declared as **full disconnection**, then the tests of Clauses 13 and 20, as specified for **full disconnection**, are made for this **intermediate position**.*

11.3.7 Exclusions for 11.3.5 and 11.3.6

The requirements of 11.3.5 and 11.3.6 shall not apply to contacts where inspection shows they cannot be operated on-load or are not intended to be operated on-load, nor to contacts which do not arc under conditions of **normal use**.

11.3.7.1 *Compliance is checked by inspection, and if necessary by the test of 11.3.7.2.*

11.3.7.2 *A d.c. voltage equal to the maximum **working voltage** is applied to the contacts in series with a resistor such that the current occurring in **normal use** is obtained. It shall not be possible to maintain an arc by slowly opening the contacts.*

11.3.8 Contacts rest position

Contacts shall, in any rest position of the **actuating member**, be either open or closed as intended, or such that no **hazard** can occur within the control or equipment.

Compliance is checked by inspection.

NOTE 1 The term "rest position of the **actuating member**" includes located, intermediate and position of **setting by the user**.

NOTE 2 For the purposes of trying to obtain an **intermediate position** of an **actuating member**, between any indexed, marked, or intended rest positions, the **actuating member** can be actuated as in **normal use**. Holding the **actuating member** in position is not **actuation**.

11.3.9 Pull-cord actuated control

A **pull-cord actuated control** shall be so designed that when the **pull-cord** is released after actuating the **control**, the relevant parts of the mechanism normally cannot fail to return to a position from which they allow the immediate performance of the next movement in the cycle of **actuation** of the **control**.

Compliance is checked by inspection and by the following test.

NOTE 1 **Pull-cord actuated controls** can be actuated from any **located position** to the next **located position** by the application and removal of a steady pull not exceeding 45 N vertically downwards, or 70 N at 45° to the vertical, with the **control** mounted in any declared manner.

NOTE 2 The actuating forces for **controls** actuated by other than **pull-cords**, are not specified. Attention is drawn to the relevant equipment standard where such requirements may be given.

11.4 Actions

11.4.1 Combined actions

A **control** having more than one action, with one of the actions designed to operate after the **failure** of the other action(s), shall be so constructed that this action remains operative after **failure** of any portion unique to the other action(s).

Compliance is checked by inspection and, if necessary, by tests after making all of the other action(s) inoperative.

11.4.2 Setting by the manufacturer

Type 2 action which has provision for **setting** by the manufacturer of its **operating value**, **operating time** or **operating sequence**, shall be designed such that it is clearly discernible if any subsequent interference with the **setting** has been made.

Compliance is checked by inspection.

11.4.3 Type 2 action

Any **type 2 action** shall be so designed that the **manufacturing deviation** and **drift** of its **operating value**, **operating time** or **operating sequence** is within the limit declared in requirements 41 and 42 of Table 1.

Compliance is checked by the tests of Clauses 15 to 17 inclusive.

11.4.4 Type 1.A or 2.A action

A Type 1.A or 2.A action shall operate to provide the **clearances** and electric strength requirements specified for **full disconnection**.

Compliance is checked by the tests of Clause 13 and the relevant requirements of Clause 20.

11.4.5 Type 1.B or 2.B action

A Type 1.B or 2.B action shall operate to provide the electric strength requirements specified for **micro-disconnection**.

Compliance is checked by the test of Clause 13 and the relevant requirements of Clause 20.

11.4.6 Type 1.C or 2.C action

A Type 1.C or 2.C action shall operate to provide circuit interruption by **micro-interruption**.

Compliance is checked by the relevant requirements of Clause 20.

11.4.7 Type 1.D or 2.D action

A Type 1.D or 2.D action shall be so designed that disconnection can neither be prevented nor inhibited, by any reset mechanism and so that after disconnection, it is not possible to reclose the circuit even momentarily while the excess or **fault** condition persists.

Compliance is checked by inspection and by test.

11.4.8 Type 1.E or 2.E action

A Type 1.E or 2.E action shall be designed so that disconnection can neither be prevented, nor inhibited by any reset mechanism and so that the contacts can neither be prevented from opening nor be maintained closed against a continuation of the excess or **fault** condition.

Compliance is checked by inspection and by test.

11.4.9 Type 1.F or 2.F action

A Type 1.F or 2.F action shall be designed so that after the **control** has been mounted in accordance with the manufacturer's instructions, it can only be reset with the aid of a **tool**.

Compliance is checked by inspection and by test.

NOTE Mounting within an equipment such that a **tool** is required to gain access to the **control** is deemed to satisfy this requirement.

11.4.10 Type 1.G or 2.G action

A Type 1.G or 2.G action shall be designed so that after the **control** has operated, it is possible to reset the **control** (although not intended) under electrically loaded conditions.

Compliance is checked by inspection and by resetting once at rated voltage and rated current.

11.4.11 Type 1.H or 2.H action

A Type 1.H or 2.H action shall be so designed that the contacts cannot be prevented from opening and which may automatically reset to the closed position if the reset means is held in the reset position. The **control** shall not reset automatically at any temperature above –35 °C with the reset mechanism in the normal position.

Compliance is checked by inspection and by test.

11.4.12 Type 1.J or 2.J action

A Type 1.J or 2.J action shall be so designed that the contacts cannot be prevented from opening, and the **control** is not permitted to function as an automatic reset device if the reset means is held in the reset position. The **control** shall not reset automatically at any temperature above –35 °C.

Compliance is checked by inspection and by test.

11.4.13 Type 1.K or 2.K action

A Type 1.K or 2.K action shall be so designed that in the event of a break in the **sensing element**, or in any other part between the **sensing element** and the **switch head**, the declared disconnection is provided before the declared **operating value**, **operating time** or **operating sequence** is exceeded.

NOTE The test is given in the relevant part 2.

11.4.14 Type 1.L or 2.L action

A Type 1.L or 2.L action shall be so designed that in the case of **failure** of the electrical supply, it performs its intended function independently of any external auxiliary energy source or electrical supply.

Compliance is checked by inspection.

NOTE A simple direct acting spring or weight is not regarded as an auxiliary energy source or electrical supply.

11.4.15 Type 1.M or 2.M action

A Type 1.M or 2.M action shall be so designed that it operates in its intended manner after the declared ageing procedure.

Compliance is checked by the test of 17.6.

11.4.16 See Annex H.

11.4.17 See Annex J.

11.5 Openings in enclosures

Drain holes, if any, shall have a minimum area of 20 mm^2, a maximum area of 40 mm^2 and minimum dimension of 3 mm.

Compliance is checked by inspection.

NOTE 1 Additional requirements for moisture resistance are contained in Clause 12.

NOTE 2 **Controls** classified as IPX7 can have a facility for opening a drain hole.

〚C〛 *Text deleted* 〚C〛

11.6 Mounting of controls

11.6.1 **Controls** shall be so designed that the methods of mounting in accordance with the manufacturer's declaration do not adversely affect compliance with this standard.

11.6.2 Declared methods of mounting shall be such that the **control** cannot rotate or be otherwise displaced, and cannot be removed from an equipment without the aid of a **tool**, if such movement or removal could adversely affect compliance with this standard. If removal or

partial removal is necessary for correct use of the **control**, then the requirements of Clauses 8, 13 and 20 shall be satisfied before and after removal.

Compliance with 11.6.1 and 11.6.2 is checked by inspection and by manual test.

NOTE **Controls**, other than those with rotary **actuation**, fixed by a nut and single bushing concentric with the **actuating means**, are deemed to comply with this requirement, provided that the tightening of the nut requires the use of a **tool**, and that the parts have adequate mechanical strength. An **incorporated control** mounted by screwless fixing is deemed to comply with this requirement if the use of a **tool** is required before the **control** can be removed from the equipment.

11.6.3 Mounting of independently mounted controls

11.6.3.1 Independently mounted controls other than those declared for panel mounting shall either:

– fit a standard box as declared;

– be supplied with a conduit box if a special conduit box is required; or

– be suitable for surface mounting on a plane surface.

11.6.3.2 If a special conduit box is required, it shall be delivered together with the **control** and the box shall be provided with the entries for conduit specified in IEC 60423.

11.6.3.3 Independently mounted controls for surface mounting used with buried installation (concealed wiring) not using an outlet box shall be provided with suitable holes on the back of the **control** allowing easy installation and connection to the terminals.

11.6.3.4 Independently mounted controls for surface mounting used with exposed wiring shall be provided with cable or conduit entries, knock-outs, or glands, which allow connection of the appropriate type of cable or conduit complying with the relevant IEC standard.

11.6.3.5 Independently mounted controls for surface mounting or the sub-bases for such **controls** shall be constructed in such a manner that the terminals for **external conductors** are accessible and can be used when the **control** or the sub-base is correctly fixed to its support and its **cover** (or the **control**) is removed.

11.6.3.6 Controls intended for mounting on an outlet box or similar enclosure shall have wiring terminals, other **live parts** and sharp-edged metal parts, earthed or not, located or protected so that they will not be forced against wiring in the box or enclosure during installation of the **control**.

11.6.3.7 Where back wiring terminals are used, they shall be recessed or be protected by close-fitting barriers or insulating materials or the equivalent that will prevent contact with wiring installed in the box.

Compliance with 11.6.3.1 to 11.6.3.7, inclusive, is checked by inspection.

Terminals that do not project into the box beyond the plane of the front edge of the box are acceptable.

Guards provided alongside terminals and extending at least 6,5 mm beyond the terminals before wiring, with a corresponding guard between double pole mechanism, are acceptable.

11.7 Attachment of cords

11.7.1 Flexing

11.7.1.1 The flexible cords of **in-line cord** and **free-standing controls** shall be capable of withstanding the flexing likely to occur in **normal use**. If a cord-guard is provided to meet this requirement it shall not be integral with the flexible cord if **type X attachment** is used.

11.7.1.2 *Compliance is checked by subjecting the **control**, fitted with the flexible cord or range of flexible cords for which it is designed, to the following test.*

11.7.1.2.1 *The **control** is mounted in the flexing apparatus shown in Figure 9. The axis of oscillation is so chosen that the weight attached to the cord and the cord itself make the minimum lateral movement during the test.*

*Samples with flat cords are mounted so that the major axis of the cross-section is parallel to the axis of oscillation. Each flexible cord passing through the inlet opening is loaded with a weight of 1 kg. A current equal to the current passing through that particular core when the **control** is operated at rated voltage is passed through each core, the voltage between cores being maximum rated voltage. The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical). The number of flexings (that is one movement through 90°) being 5 000, and the rate of the flexing being 60 flexings per minute.*

11.7.1.2.2 *After the test, the sample shall show no damage within the meaning of this standard. During the test, no interruption of the current and no short circuit between the individual conductors shall occur, neither shall broken strands pierce the insulation to the outer surface of the accessory. A short circuit between individual conductors is considered to occur if the current reaches twice the value of the test current.*

11.7.1.2.3 *Not more than 10 % of the total number of conductors of the flexible cord shall have been broken.*

11.7.2 Cord anchorages

11.7.2.1 **Controls** other than those **integrated** and **incorporated**, intended to be connected by means of a **non-detachable cord**, shall have cord anchorages such that the conductors are relieved from strain, including twisting, where they are connected to the terminals, and that their covering is protected from abrasion. It shall be clear how the relief from strain and the prevention of twisting is intended to be effected.

11.7.2.2 Cord anchorages of **class II controls** shall be of insulating material or, if of metal, be insulated from accessible metal parts or metal foil over accessible non-metallic surfaces by insulation complying with the requirements for **supplementary insulation**.

11.7.2.3 Cord anchorages of **controls** other than those of class II shall be of insulating material or be provided with an insulating lining, if otherwise an insulation **fault** on the cord could make accessible metal parts live. This lining, if any, shall be fixed to the cord anchorage, unless it is a bushing which forms part of a cord guard provided to meet the requirements of 11.7.1.

11.7.2.4 Cord anchorages shall be so designed that:

– the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible metal parts;

– the cord is not clamped by a metal screw which bears directly on the cord;

– for **type X attachment** or **type M attachment**, at least one part is securely fixed to the **control**;

– for **type X attachment** or **type M attachment**, replacement of the flexible cord does not require the use of a **special purpose tool**;

– for **type X attachment**, they are suitable for the different types of flexible cord which may be connected;

– for **type X attachment**, the design and location make replacement of the flexible cord easily possible.

11.7.2.5 For other than **type Z attachment**, makeshift methods such as tying the cord into a knot, or tying the ends with string, shall not be used.

11.7.2.6 Glands shall not be used as cord anchorages in **in-line cord controls** using **type X attachment** unless they make provision for clamping all types and sizes of cords used in 10.1.4.

11.7.2.7 Screws, if any, which have to be operated when replacing the cord, shall not serve to fix any other component, unless either the **control** is rendered inoperable or manifestly incomplete if they are omitted or incorrectly replaced, or the component intended to be fixed cannot be removed without the aid of a **tool** when replacing the flexible cord.

11.7.2.8 *Compliance with 11.7.2.1 to 11.7.2.7, inclusive, is checked by inspection and by the tests of 11.7.2.9 to 11.7.2.15 inclusive. Integrated and **incorporated controls**, intended for the connection of flexible cords, are tested according to the relevant standard for the equipment in which they are integrated or incorporated.*

11.7.2.9 *The **control** is fitted with a flexible cord and the conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the intended manner, the screws being tightened with a torque equal to two-thirds of the torque specified in 19.1.*

11.7.2.10 *After this preparation, it shall not be possible to push the cord into the **control** to such an extent that the cord or internal parts of the **control** could be damaged, or that internal parts are interfered with in a way which might impair compliance with this standard.*

11.7.2.11 *The cord is then subjected to pulls of the value and number shown in Table 9. The pulls are applied in the most unfavourable direction, without jerks, each time for 1 s.*

11.7.2.12 *Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in Table 9.*

Table 9 (11.7.2 of edition 3) – Pull and torque values

Control	Pull [a] N	Torque [a] Nm	Number of pulls [a]
Free-standing controls and **independently mounted controls**:			
Up to and including 1 kg	30	0,1	25
Over 1 kg up to and including 4 kg	60	0,25	25
Over 4 kg	100	0,35	25
In-line cord controls (other than **free-standing controls**)	90	0,25	100
[a] Some equipment standards may require a different value.			

11.7.2.13 *For **type X attachment**, the tests are made first with the lightest permissible type of flexible cord of the smallest cross-sectional area used in 10.1.4, and then with the next*

*heavier type of flexible cord of the largest cross-sectional area used. For **type M attachment**, **type Y attachment** or **type Z attachment**, only declared or fitted cord is used.*

11.7.2.14 *During the tests, the cord shall not be damaged. After the tests, the cord shall not have been displaced longitudinally by more than 2 mm, the conductors shall not have been moved over a distance of more than 1 mm in the terminals, and there shall be no appreciable strain at the connection. **Creepage distances** and **clearances** shall not have been reduced below the value specified in Clause 20.*

11.7.2.15 For the measurement of the longitudinal displacement, a mark is made on the cord while it is subjected to the pull, at a distance of approximately 20 mm from the cord anchorage, before starting the tests. After the tests, the displacement of the mark on the cord in relation to the cord anchorage is measured while the cord is subjected to the pull.

11.8 Size of cords – non-detachable

11.8.1 Non-detachable cords shall not be lighter than ordinary tough rubber sheathed flexible cord, designated 〚C〛 EN 50525-2-21 〚C〛, or ordinary polyvinyl chloride sheathed flexible cord, designated 〚C〛 EN 50525-2-21〚C〛. The use of a lighter flexible cord is permissible if allowed in a particular equipment standard or for connection to external **SELV** devices (sensors/units).

Compliance is checked by inspection.

11.8.2 Controls fitted with **non-detachable cords** shall have a cord with conductors of a size not less than that shown in Table 10.

Table 10 (11.8.2 of edition 3) – Minimum cord conductor sizes

Current in relevant circuit [a] A	**Nominal cross-sectional area** mm^2
Up to and including 6 [c]	0,75
over 6 up to and including 10	1
over 10 up to and including 16	1,5
over 16 up to and including 25	2,5
over 25 up to and including 32	4
over 32 up to and including 40	6
over 40 up to and including 63	10

[a] Requirements for applications greater than 63 A are under consideration.

[b] 〚C〛 Void 〚C〛

[c] Lower values than 0,75 mm^2 are permitted for **class III controls** or if permitted in a particular equipment or installation standard.

Compliance is checked by inspection.

11.8.3 The space for the flexible cord inside the **control** shall be adequate to allow the conductors to be easily introduced and connected, and the **cover**, if any, fitted without **risk** of damage to the conductors or their insulation. It shall be possible to check that the conductors are correctly connected and positioned before the **cover** is fitted.

Compliance is checked by inspection and by connecting cords of the largest cross-sectional area used in 10.1.4.

11.9 Inlet openings

11.9.1 Inlet openings for flexible external cords shall be so designed and shaped, or shall be provided with an inlet bushing, so that the covering of the cord can be introduced without **risk** of damage.

11.9.1.1 Conduit entries and knock-outs of **independently mounted controls** shall be so designed or located that introduction of the conduit or conduit fitting does not affect the protection against electric shock or reduce **creepage distances** and **clearances** below the values specified in Clause 20.

Compliance is checked by inspection.

11.9.2 If an inlet bushing is not provided, then the inlet opening shall be of insulating material.

11.9.3 If an inlet bushing is provided, then it shall be of insulating material, and

– shall be so shaped as to prevent damage to the cord,
– shall be reliably fixed,
– shall not be removable without the aid of a **tool**,
– shall, if **type X attachment** is used, not be integral with the cord.

11.9.4 An inlet bushing shall not be of rubber, with the exception that for **type M attachment**, **type Y attachment** and **type Z attachment** for **class 0 control**, **class 0I control** or **class I control**, rubber is allowed if the bushing is integral with the sheath of a cord of rubber ⟦C⟩ see Annex ZB. ⟨C⟧

Compliance with 11.9.1 to 11.9.4, inclusive, is checked by inspection and manual test.

11.9.5 Enclosures of **independently mounted controls** intended to be permanently connected to **fixed wiring** shall have cable entries, conduit entries, knockouts or glands which permit the connection of the appropriate conduit, cable or cord, as applicable.

11.10 Equipment inlets and socket-outlets

11.10.1 The design of equipment inlets and socket-outlets intended for use by the **user** for the interconnection of **controls** and equipment shall be such as to render unlikely their engagement with each other or with equipment inlets or socket-outlets intended for other **systems** if such engagement could result in fire, or injury or electric shock to persons or damage to equipment or surroundings.

Compliance is checked by inspection.

11.10.2 **In-line cord controls** provided with an equipment inlet or socket-outlet shall be so rated, or so protected, that unintentional overloading of either the **control**, equipment inlet or socket-outlet cannot occur in **normal use**.

Compliance is checked by inspection.

11.10.3 **Controls** provided with pins, blades, or other connecting/adapting means, in order to be introduced into fixed socket outlets shall comply with the requirements of the appropriate socket-outlet system.

If **in-line cord controls** provided with a plug and a socket outlet, where the plug can be connected to a socket outlet rated for a higher load current than the **control**, the **control** shall be provided with an incorporated fuse or a protective device to limit the current to the **control**'s rating. The testing of the protective function is done in the sequence of tests according to 27.5.

The plug and socket outlet part of the **control** shall comply with the appropriate standard for the plug and socket system. The **control** part shall comply with this standard.

〚C〛 *Text deleted* 〚C〛

Compliance is checked by inspection and by carrying out tests based on those prescribed for the socket-outlet system.

11.11 Requirements during mounting, maintenance and servicing

11.11.1 Covers and their fixing

11.11.1.1 For other than **integrated controls**, the removal of a **cover** or **cover plate**, including battery compartment **cover**, which is intended to be removed during mounting, **user maintenance** or **servicing** of the **control** or equipment, shall not affect the **setting** of the **control** if this might impair compliance with this standard.

11.11.1.2 The fixing of **covers** shall be such that they cannot be displaced, nor replaced incorrectly if this could mislead the **user** or would impair compliance with this standard. The fixing of **covers** which need to be removed for mounting shall not serve to fix any parts, other than **actuating members** or gaskets.

Compliance with 11.11.1.1 and 11.11.1.2 is checked by inspection.

〚C〛 *Text deleted* 〚C〛

11.11.1.3 Covers of enclosures

NOTE 〚C〛 Void 〚C〛

11.11.1.4 Glass covering an opening

NOTE 〚C〛 Void 〚C〛

11.11.1.5 Non-detachable parts

Non-detachable parts which provide the necessary degree of protection against electric shock, moisture or contact with moving parts shall be fixed in a reliable manner and shall withstand the mechanical stress occurring in **normal use**.

Snap-in devices used for fixing non-detachable parts shall have an obvious locked position. The fixing properties of snap-in devices used in parts which are likely to be removed for installation or during **servicing** shall not deteriorate.

Compliance is checked by the tests of 11.11.1.5.1 to 11.11.1.5.3.

11.11.1.5.1 *Parts which are likely to be removed for installation or during **servicing** are disassembled and assembled 10 times before the test is carried out.*

NOTE **Servicing** includes replacement of the supply cord.

11.11.1.5.2 *For the tests of 11.11.1.5.3, the **control** shall be at room temperature. However, in cases where compliance may be affected by temperature, the test is also carried out immediately after the **control** has been operated under the conditions specified in Clause 14.*

11.11.1.5.3 *A force is applied for 10 s, without jerks, in the most unfavourable direction, to those areas of the **cover** or part which are likely to be weak. The force to be used shall be as follows:*

– *Push force* *50 N*

– *Pull force, as follows:*

  a) *If the shape of the part is such that the fingertips cannot easily slip off* *50 N*

  b) *If the projection of the part which is gripped is less than 10 mm in the direction of removal* *30 N*

The push force is applied by means of a rigid test finger similar in dimensions to the standard test finger shown in Figure 2.

The pull force is applied by any suitable means (for example, a suction cup) so that the test results are not affected.

While the pull test of a) or b) is being applied, the test fingernail shown in Figure 3 is inserted in any aperture or joint with a force of 10 N. The fingernail is then slid sideways with a force of 10 N; it is not twisted or used as a lever.

If the shape of the part is such that an axial pull is unlikely, no pull force is applied but the test fingernail shown in Figure 3 is inserted in any aperture or joint with a force of 10 N and is then pulled for 10 s by means of the loop with a force of 30 N in the direction or removal.

*If the **cover** or part is likely to be subjected to a twisting force, a torque as detailed below shall be applied at the same time as the pull or push force:*

– *for major dimensions up to and including 50 mm* *2 Nm*

– *for major dimensions over 50 mm* *4 Nm*

This torque is also applied when the test fingernail is pulled by means of the loop.

If the projection of the part which is gripped is less than 10 mm, the above torque is reduced to 50 % of the value.

11.11.1.5.4 *During and after the tests of 11.11.1.5.3, parts shall not become detached and they shall remain in the locked position, otherwise they are deemed to be **detachable parts**.*

11.11.1.6 A **cover**, which can be removed with one hand, shall not be released when a squeezing force of up to 45 N combined with up to 15 N for the pull test is applied at any two points, the distance between which does not exceed 125 mm, as measured by a tape stretched tightly over that portion of the surface of the **cover** which would be encompassed by the palm of the hand. The test is performed before and after 10 removal and replacement **operations**.

11.11.2 Cover fixing means

Fixing screws of **covers** or **cover plates** which need to be removed during mounting, **user maintenance** or **servicing** shall be captive.

Compliance is checked by inspection.

NOTE The use of tight-fitting washers of cardboard or similar material is deemed to meet this requirement. See 19.1.5.

11.11.3 Actuating member

11.11.3.1 A **control** shall not be damaged when its **actuating member** is mounted or removed in the intended manner.

11.11.3.2 If the maximum or minimum **setting** by the manufacturer or **setting by the user** of a **type 2 action** is limited by mechanical means associated with an **actuating member**, such **actuating member** shall not be removable without the use of a **tool**.

11.11.3.3 If an **actuating member** of a **control** with a **type 1 action** providing an "OFF" position, or the **actuating member** of any **control** with a **type 2 action** is used to indicate the condition of the **control**, it shall not be possible to fix the **actuating member** in an incorrect position.

*Compliance with 11.11.3.1 to 11.11.3.3 inclusive is checked by inspection and, for **actuating members** which do not require a **tool** for their removal, by the test of 18.9.*

NOTE Standards for equipment may require that an **actuating member** used to indicate the condition of a **control** not be capable of being fixed in an incorrect position.

11.11.4 Parts forming supplementary insulation or reinforced insulation

Parts of **controls** which serve as **supplementary insulation** or **reinforced insulation** and which might be omitted during reassembly after **user maintenance** or **servicing**, shall either be fixed in such a way that they cannot be removed without being seriously damaged, or be so designed that they cannot be replaced in an incorrect position, and that, if they are omitted, the **control** is rendered inoperable or manifestly incomplete.

Compliance is checked by inspection.

NOTE Lining metal enclosures with a coating of lacquer, or with other material in the form of a coating which can be easily removed by scraping, is not deemed to meet this requirement.

11.11.5 Sleeving as supplementary insulation

Sleeving used as **supplementary insulation** on **integrated conductors** shall be retained in position by a positive means.

Compliance is checked by inspection and by manual test.

NOTE A sleeve is considered to be fixed by a positive means if it can only be removed by breaking or cutting, or if it is clamped.

11.11.6 Pull-cords

Pull-cords shall be insulated from **live parts** and the **control** shall be so designed that it is possible to fit or to replace the **pull-cord** without **live parts** becoming accessible.

Compliance is checked by inspection.

11.11.7 Insulating linings

Insulating linings, barriers and the like shall have adequate mechanical strength and shall be secured in a reliable manner.

Compliance is checked by inspection.

11.12 Controls using software

See Annex H.

11.13 Protective controls and components of protective control systems

11.13.1 Protective controls

Protective controls shall

– be so designed and constructed as to be reliable and suitable for their intended duty and take into account the maintenance and testing requirements of the devices, where applicable,

– be independent of other functions, unless their safety function cannot be affected by such other functions,

– comply with appropriate design principles in order to obtain suitable and reliable protection.

These principles include, in particular, fail-safe modes, redundancy, diversity, and self-diagnosis.

Operating controls shall not be used as **protective controls**.

Compliance is checked by carrying out the relevant tests specified in this standard and the appropriate part 2.

11.13.2 Pressure limiting devices

These devices shall be so designed that the pressure will not permanently exceed the maximum allowable pressure of the controlled application; however, a short duration pressure surge of no more than 10 % of the maximum allowable pressure is acceptable, where appropriate, or where not specified in the relevant standard for the controlled application.

11.13.3 Temperature monitoring devices

These devices shall have an adequate response time on safety grounds, consistent with measurement function.

11.13.4 Batteries

11.13.4.1 **Controls** containing batteries shall be designed to reduce the **risk** of fire, explosion and chemical leaks under normal conditions and after a single **fault** in the **control**. For **user**-replaceable batteries, the design shall reduce the likelihood of reverse polarity installation if this would create a **hazard**.

11.13.4.2 Battery circuits designed for a total battery capacity > 1 000 mAh shall be designed so that:

– the output characteristics of a battery charging circuit are compatible with its rechargeable battery (see Annex V); and

– for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented; and

– for rechargeable batteries (see Annex V), charging and discharging at a rate exceeding the battery manufacturer's recommendations, and reversed charging, are prevented; and

– replaceable batteries shall either:

  - have contacts that cannot be shorted with the test finger (Figure 2); or
  - be inherently protected to avoid creating a **hazard** within the meaning of the standard.

NOTE Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

11.13.4.3 If a battery with a capacity > 1 000 mAh contains liquid or gel electrolyte, a battery tray shall be provided that is capable of retaining any liquid that could leak as a result of internal pressure build-up in the battery. The requirement to provide a battery tray does not apply if the construction of the battery is such that leakage of the electrolyte from the battery is unlikely.

NOTE An example of a battery construction where leakage of the electrolyte is considered to be unlikely is the sealed **cell** valve-regulated type.

11.13.4.3.1 If battery tray is required, its capacity shall be at least equal to the volume of electrolyte of all the **cells** of the battery, or the volume of a single **cell** if the design of the battery is such that simultaneous leakage from multiple **cells** is unlikely.

NOTE If several **cells** (for example, the six **cells** in a 12 V lead-acid battery) are in a single casing, its fracture could lead to a greater volume of leakage than from a single **cell**.

11.13.4.4 *Compliance with 11.13.4.1 to 11.13.4.3.1 is checked by inspection and by evaluation of the data provided by the **equipment manufacturer** and battery manufacturer.*

*When appropriate data is not available, compliance is checked by the test of 11.13.4.4.1 to 11.13.4.4.4 and 11.13.4.5. However, batteries that are inherently safe for the conditions given are not tested under those conditions. Consumer grade, non-rechargeable carbon-zinc or alkaline batteries are considered safe under short-circuiting conditions and therefore are not tested for discharge; nor are such batteries tested for leakage under storage conditions. The battery used for the following tests is a new non-rechargeable battery or as provided with, or recommended by the manufacturer for use with, the **control**.*

11.13.4.4.1 *Unintentional charging of a non-rechargeable battery. The battery is charged while briefly subjected to the simulation of any single component **failure** that is likely to occur in the charging circuit and that would result in unintentional charging of the battery. To minimize testing time, the **failure** is chosen that causes the highest charging current. The battery is then charged for a single period of 7 h with that simulated **failure** in place.*

11.13.4.4.2 *Excessive discharging rate. The battery is subjected to rapid discharge by open-circuiting or short-circuiting any current-limiting or voltage-limiting components in the load circuit of the battery under test.*

NOTE Some of the tests specified can be hazardous to the persons carrying them out; it is suggested that all appropriate measures to protect personnel against possible chemical or explosion **hazards** be taken.

11.13.4.4.3 *See Annex V.*

11.13.4.4.4 *These tests shall not result in any of the following:*

– *chemical leaks caused by cracking, rupturing or bursting of the battery jacket, if such leakage could adversely affect required insulation; or*

– *spillage of liquid from any pressure relief device in the battery, unless such spillage is contained by the **control** without **risk** of damage to the insulation or **harm** to the **user**; or*

– *explosion of the battery, if such explosion could result in injury to a **user**; or*

– *emission of flame or expulsion of molten metal to the outside of the **control** enclosure.*

11.13.4.5 *After completion of the tests, the equipment is subjected to the electric strength tests of 13.2.*

〖A1〗11.13.5 Smart enabled controls〖A1〗

[A1] **11.13.5.1** A **smart enabled control** shall be so designed that the external communication signals (data or power demand) do not unintentionally override the operating parameters of a **type 2 action control** nor interfere with any protective function of the **control**.

A **smart enabled control** is permitted to alter the operating parameters of a type 2 **control** within defined limits so long as the protective functions remain intact.

11.13.5.2 A **smart enabled control** that integrates operating and protective functions shall be evaluated as a **protective control**.

11.13.5.3 Any transmitter or communication module that is external to the **control** and acts as the interface between the **control** and the telecommunication network shall comply with IEC 62151 or IEC 62368-1. Nevertheless the measures to ensure protection against electric shock in this standard (e.g. Annex T) shall be met.

11.13.5.4 Any transmitter or communication module that is part of the **smart enabled control** shall comply with the requirements of this standard.

11.13.5.5 *Compliance of 11.13.5 is checked by evaluating the **control** in accordance with the requirements of H.27.1 and other relevant requirements of this standard.* [A1]

12 Moisture and dust resistance

12.1 Protection against ingress of water and dust

12.1.1 **Controls** shall provide the degree of protection against ingress of water and dust appropriate to their IP classification when mounted and used in the declared manner.

12.1.2 *Compliance is checked by first preparing the **control** as described in 12.1.3 to 12.1.6 inclusive and then by carrying out the appropriate test specified in IEC 60529. Immediately after the appropriate test the **control** shall withstand the electric strength test specified in 13.2, and inspection shall show that any water which may have entered the **control** has not impaired compliance with this standard: in particular, there shall be no trace of water on insulation which could result in reduction of **creepage distances** and **clearances** below the values specified in Clause 20.*

12.1.3 ***Controls** are allowed to stand in normal test room atmosphere for 24 h before being subjected to the appropriate test.*

12.1.4 ***Controls** provided with a **detachable cord** are fitted with an appropriate equipment inlet and flexible cord; **controls** with a **non-detachable cord** using **type X attachment** are fitted with the appropriate conductors with the smallest cross-sectional area specified in 10.1.4; **controls** provided with a **non-detachable cord** using **type M attachment**, **type Y attachment** or **type Z attachment** are tested with the cord declared or delivered with the samples.*

12.1.5 ***Detachable parts** are removed and subjected, if necessary, to the tests with the main part.*

12.1.6 *Sealing rings of glands and other sealing means, if any, are aged in an atmosphere having the composition and pressure of the ambient air, by suspending them freely in a heating cabinet, ventilated by natural circulation. They are kept in the cabinet at a temperature of (70 ± 2) °C, for 10 days (240 h).*

[C] *Text deleted* [C]

12.1.6.1 Void

12.1.6.2 *Immediately after ageing, the parts are taken out of the cabinet and left at room temperature, avoiding direct daylight, for at least 16 h, before being reassembled. The glands and other sealing means are then tightened with a torque equal to two-thirds of that given in Table 20.*

12.2 Protection against humid conditions

12.2.1 All **controls** shall withstand humid conditions which may occur in **normal use**.

See also Annex J.

12.2.2 *Compliance is checked by the test sequence described in 12.2.3, after the humidity treatment of 12.2.5 to 12.2.9, inclusive.*

12.2.3 *For **in-line cord**, **free-standing**, **independently mounted controls**, the test of 13.2 is conducted immediately after the humidity treatment. For integrated and **incorporated controls**, the test of 13.2 is conducted immediately after the humidity treatment. These tests shall be conducted in such a manner that condensation does not occur on any surface of the test samples.*

12.2.4 *The **control** shall show no damage so as to impair compliance with this standard.*

12.2.5 *Cable inlet openings, if any, and drain holes are left open. If a drain hole is provided for an IPX7 **control**, it is opened.*

12.2.6 ***Detachable parts** are removed and subjected, if necessary, to the humidity treatment with the main part.*

12.2.7 *Before being placed in the humidity cabinet, the sample is brought to a temperature between t and (t + 4) °C. The sample is then kept in the humidity cabinet for:*

– *2 days (48 h) for IPX0 **controls**;*
– *7 days (168 h) for all other **controls**.*

12.2.8 *The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity between 91 % and 95 %. The temperature of the air, at all places where samples can be located, is maintained within 1 K of any convenient value (t) between 20 °C and 30 °C.*

12.2.9 *After this treatment, the tests of Clause 13 are made either in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature after the reassembly of any detached parts.*

NOTE 1 In most cases, the sample can be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.

NOTE 2 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air. It is important that care be taken such that the test sample is not subjected to condensate or other contaminants from the salt solution or from any part of the test equipment.

NOTE 3 In order to achieve the specified conditions within the cabinet, it is necessary to provide constant circulation of the air within and, in general, to use a cabinet which is thermally insulated.

〖C〗 *Text deleted* 〖C〗

13 Electric strength and insulation resistance

13.1 Insulation resistance

The insulation resistance of **in-line cord**, **free standing** and **independently mounted controls** shall be adequate.

13.1.1 *Compliance is checked by the test of 13.1.2 to 13.1.4 inclusive. This test is made when specified in Clause 12.*

13.1.2 *When measuring **reinforced insulation** or **supplementary insulation** to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.*

13.1.3 *The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

13.1.4 *The insulation resistance shall not be less than that shown in Table 11.*

Table 11 (13.1 of edition 3) – Minimum insulation resistance

Insulation to be tested	Insulation resistance MΩ
Functional insulation	–
Basic insulation	2
Supplementary insulation	5
Reinforced insulation	7

13.2 Electric strength

The electric strength of all **controls** shall be adequate.

13.2.1 *Compliance is checked by the following test of 13.2.2 to 13.2.4 inclusive, using insulation or disconnection test voltages as shown in Table 12. This test is made when specified in Clause 12 and Clause 17.*

Table 12 (13.2 of edition 3) – Insulation or disconnection test voltages [a] *(1 of 2)*

Insulation or disconnection to be tested [c d]	Test voltage for working voltage (U) [q]		
	SELV [e]	**Working voltage** ≤ 50 V [f]	**Working voltage** [f] 50 V < U ≤ 690 V
Functional insulation [g]	100	100	2 × U
Basic insulation [h i]	500	1 250	1 200 + U
Supplementary insulation [h i j k l]	–	1 250	1 200 + (U)
Reinforced insulation [h i j k l]	–	2 500	2 400 + (2 × U)
Full disconnection [o]	N/A	1 250	1 200 + U
Micro-disconnection [o]	100	100	2 × U
Electronic disconnection [m n]	100	100	–

Micro-interruption [p]	–	–	–

NOTE 1 A DC potential equivalent to 1,414 times the test voltage specified in Table 12 may be applied.

NOTE 2 For **controls** intended for incorporating into an appliance or in conjunction with other equipment the higher electric strength test values of the equipment standard can be considered.

[a] 〚C〛 Void 〚C〛

[b] 〚C〛 Void 〚C〛

[c] Special components which might render the test impractical, such as electronic parts, neon lamps, coils or windings shall be disconnected at one pole or bridged as appropriate to the insulation being tested. Capacitors shall be bridged except for the tests for **functional insulation** when one pole is disconnected. Where such a proceeding is not practical, the tests of Clauses 15 to 17 inclusive are considered to be sufficient.

[d] For **class I controls** and **class 0I controls** and **controls** for class I situations, care shall be taken that adequate **clearance** is maintained between metal foil and accessible metal to avoid over-stressing of insulation insulation between **live parts** and earthed metal parts. 〚C〛 See Annex ZB.〚C〛

[e] No requirement up to 24 V a.c. r.m.s. if the circuit is insulated from the mains by **double insulation** or **reinforced insulation** (may be earthed).

[f] Applies to **controls** galvanically connected to mains.

[g] **Functional insulation** on printed wiring boards submitted in **normal use** to a voltage up to 50 V is not subjected to the tests of 13.2.

[h] See 13.3.1.

[i] Any metal in contact with accessible metal is also regarded as accessible.

[j] For the tests of **supplementary insulation** and **reinforced insulation**, the metal foil is applied in such a way that sealing compound, if any, is effectively tested to accessible insulating surfaces.

[k] For **accessible parts** which are protected by means of **protective impedance**, the tests are carried out with the components disconnected, the mid-point of the two impedances being regarded as an intermediate metal part.

[l] For **controls** incorporating **reinforced insulation** as well as **double insulation**, care should be taken that the voltage applied to the **reinforced insulation** does not over-stress the **basic insulation** or the supplementary parts of the **double insulation**.

[m] The device which actually performs the disconnection is first removed from the circuit. If necessary, any **control** input is connected such that the device is providing the disconnection. The test voltage is then applied to the terminals and **terminations** of the device which carry the load current.

[n] See Clause H.28.

[o] For the test of **full disconnection** and **micro-disconnection**, contacts are opened automatically or manually and tested as soon after opening as possible to ensure that the contact separation and the supporting insulation are satisfactory.

In the case of temperature **sensing controls**, it may be necessary to provide special samples specially calibrated to open between 15 °C and 25 °C to enable this test to be carried out at room temperature immediately after removal from the humidity cabinet.

[p] There are no electric strength requirements for **micro-interruption**, since the satisfactory completion of the tests of Clauses 15 to 17 inclusive are considered to be sufficient. Furthermore, for a **control** which has no **micro-disconnection** in one position of its **actuating means** and **micro-interruption** in other positions, there are no requirements for electric strength for those positions corresponding to **micro-interruption**.

[q] All a.c. voltages are r.m.s. at 50 Hz to 60 Hz. 〚A1〛

13.2.2 *When measuring **reinforced insulation** or **supplementary insulation** to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.*

13.2.3 *The insulation is subjected to a voltage of substantially sine-wave form, having frequency of 50 Hz or 60 Hz. Voltage is applied for 1 min across the insulation or disconnection indicated in Table 12 and has the value shown in the table.*

13.2.4 *Initially not more than half the prescribed voltage is applied, then it is raised rapidly to the full value. No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.*

〚C〛 *Text deleted* 〚C〛

14 Heating

14.1 **Controls** and their supporting surfaces shall not attain excessive temperatures in **normal use**.

14.1.1 *Compliance is checked by the test of 14.2 to 14.7 inclusive.*

14.1.2 *During this test, the temperatures shall not exceed the values specified in Table 13, and the **controls** shall not undergo any change so as to impair compliance with this standard and in particular with Clauses 8, 13 and 20.*

14.2 *Terminals and **terminations** which are intended for the connection of **external conductors**, other than those for **non-detachable cords** using **type M attachment**, **type Y attachment** or **type Z attachment**, shall be fitted with conductors of the intermediate cross-sectional area appropriate to the type of conductor and rating used in 10.1.4.*

14.2.1 *If **type M attachment**, **type Y attachment** or **type Z attachment** are used then the cord declared or supplied shall be used for the test.*

14.2.2 *If a terminal is suitable for both flexible cords and for fixed conductors, then the appropriate flexible cord is used.*

14.2.3 *Terminals not intended for the connection of **external conductors** shall be fitted with conductors of the minimum cross-sectional area, as specified in 10.2.1, or with a special conductor if declared in 7.2.*

14.3 ***In-line cord controls** are stood or rested on a dull black painted plywood surface.*

14.3.1 ***Independently mounted controls** are mounted as in **normal use**.*

14.4 ▌C〉*All circuits and terminals intended to control external loads shall be loaded as declared in Table 1, requirement 3, such that each circuit or terminal carries that current between 0,9 and 1,1 of its declared rating that will prove most arduous. All controls shall be tested at a voltage between 0,9 and 1,1 times rated voltage but controls that are not sensitive to boltage may be tested at a lower voltage provided that 1,1 times rated current is passed. Internal circuits shall be connected as specified by the manufacturer.* 〈C▐

14.4.1 *Circuits and contacts not intended for external loads shall be specified by the manufacturer.*

14.4.2 ***Actuating members** are placed in the most unfavourable position.*

14.4.3 *Contacts required to be closed initially for the purpose of this test are closed at the rated current and the rated voltage of the circuit.*

14.4.3.1 *For temperature **sensing controls**, the temperature **sensing element** is raised or lowered to a temperature which differs from the measured operating temperature under the conditions of this clause (5 ± 1) K such that the contacts are then in the closed position.*

14.4.3.2 *For all other **sensing controls**, the **sensing element** shall be maintained such that the contacts are in the closed position, but are as near the point of opening as is practical.*

14.4.3.3 *It may be necessary to raise or lower, as appropriate, the value of the **activating quantity** beyond the **operating value** so as to cause **operation** and then to return the value of **activating quantity** to the required level.*

14.4.3.4 *For other **automatic controls**, the most arduous **operating sequence** or segment of the **operating sequence** shall be selected.*

14.4.4 *If the **control** starts to operate during this test, the **control** is reset so that the contacts will remain closed.*

14.4.4.1 *If resetting to reclose the contacts is not practical, then the test is discontinued. A new **operating value** is determined and the test repeated using this new **operating value**.*

14.5 ***Controls** are tested in an appropriate heating and/or refrigerating apparatus such that the conditions in 14.5.1 and 14.5.2 are obtained.*

*Except for **controls** submitted in or with appliances, the test shall be conducted in an **environment** protected from drafts. Natural convection is permitted.*

14.5.1 *The temperature of the **switch head** is maintained between T_{max} and either (T_{max} + 5) °C or 1,05 times T_{max}, whichever is greater. The temperature of any mounting surface is maintained between $T_{s\ max}$ and either ($T_{s\ max}$ + 5) °C or 1,05 times $T_{s\ max}$ whichever is the greater if $T_{s\ max}$ is different from T_{max}.*

14.5.2 ***In-line cord controls**, **independently mounted controls** and those parts of **integrated** and **incorporated controls** which are accessible when the **control** is mounted as in **normal use** shall be in a room temperature in the range of 15 °C to 30 °C, the resulting measured temperature being corrected to a 25 °C reference value.*

14.6 *The temperatures specified for the **switch head**, the mounting surfaces and **sensing element** shall be attained in approximately 1 h.*

14.6.1 *The electrical and thermal conditions are maintained for 4 h, or for 1 h after steady state, whichever occurs first.*

14.6.2 *For **controls** designed for short-time or intermittent **operation**, the resting time(s) declared in Table 1, requirement 34, shall be included in the 4 h.*

14.7 *The temperature of the medium in which the **switch head** is located, and the value of the **activating quantity** to which the **sensing element** is exposed, shall be measured as near as possible to the centre of the space occupied by the samples and at a distance of approximately 50 mm from the **control**.*

14.7.1 *The temperature of the parts and surfaces indicated in Table 13 shall be determined by means of fine wire thermocouples or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the part under test.*

14.7.2 *Thermocouples used for determining the temperature of supporting surfaces are attached to the back of small blackened discs of copper or brass, 15 mm in diameter and 1 mm thick, which are flush with the surface. So far as is possible, the **control** is positioned such that parts likely to attain the highest temperatures touch the discs.*

14.7.3 *In determining the temperature of **actuating members** and other handles, knobs, grips and the like, consideration is given to other parts which are gripped in **normal use**, and if of non-metallic material to parts in contact with hot metal.*

14.7.4 *The temperature of electrical insulation, other than that of windings, is determined on the surface of the insulation at places where **failure** could cause:*

- *a short circuit;*
- *a fire **hazard**;*
- *an adverse effect on the protection against electric shock;*
- *contact between **live parts** and accessible metal parts;*
- *bridging of insulation;*
- *reduction of **creepage distances** or **clearances** below the values specified in Clause 20.*

Table 13 (14.1 of edition 3) – Maximum heating temperatures *(1 of 3)*

Parts	Maximum temperature permitted °C
Pins of appliance inlets and plug-in devices [a]:	
– for very hot conditions	155
– for hot conditions	120
– for cold conditions	65
Windings [b c d e] and core laminations in contact therewith, if winding insulation is:	
– of class A material	100 [90]
– of class E material	115 [105]
– of class B material	120 [110]
– of class F material	140
– of class H material	165
Terminals and **terminations** for **external conductors** [a f g]	85
Other terminals and **terminations** [a h]	85
Rubber or polyvinyl chloride insulation of conductors: [a]	
– if flexing occurs or is likely to occur	60
– if no flexing occurs or is likely to occur	75
– with temperature marking or temperature rating	value marked
Cord sheath used as **supplementary insulation** [i]	60
Rubber other than synthetic when used for gaskets or other parts, the deterioration of which could impair compliance with this standard:	
– when used as **supplementary insulation** or as **reinforced insulation**	65
– in other cases	75
Materials used as insulation other than for wires [i j k]:	
– impregnated or varnished textile, paper or press board	95
– laminates bonded with:	
melamine formaldehyde, phenol-formaldehyde or phenol-furfural resins	110 [200]
urea-formaldehyde resins	90 [175]
– mouldings of [j]	
phenol-formaldehyde, with cellulose fillers	110 [200]
phenol-formaldehyde, with mineral fillers	125 [225]
melamine-formaldehyde	100 [175]
urea-formaldehyde	90 [175]
polyester with glass fibre reinforcement	135
pure mica and tightly sintered ceramic material when such products are used as **supplementary insulation** or **reinforced insulation**	425
other thermosetting materials and all thermo-plastic material [l]	–
All **accessible surfaces** except those of **actuating members**, handles, knobs, grips and the like	85

Table 13 *(2 of 3)*

Parts	Maximum temperature permitted °C
Accessible surfaces of handles, knobs, grips and the like used for carrying and transporting the **control**:	
– of metal	55
– of porcelain or vitreous material	65
– of moulded material, rubber or wood	75
Accessible surface of **actuating members**, or of other handles, grips or the like which are held for short periods only:	
– of metal	60
– of porcelain or vitreous material	70
– of moulded material, rubber or wood	85
Wood in general	90
Supported painted plywood surface	85
Current-carrying parts made of copper or brass [a m n]	230
Current-carrying parts made of steel [a]	400
Other current-carrying parts [a m]	–

[a] For these parts, the tests of 14.7 are repeated after Clause 17.

[b] The classification is in accordance with IEC 60085.

Examples of class A material are: impregnated cotton, silk, artificial silk and paper; enamels based on oleo- or polyamide resins.

Examples of class B material are: glass fibre, melamine and phenol formaldehyde resins.

Examples of class E material are:

– mouldings with cellulose fillers, cotton fabric laminates and paper laminates, bonded with melamine- formaldehyde, phenol-furfural resins;

– cross-linked polyester resins, cellulose triacetate films, polyethylene terephthalate films;

– varnished polyethylene terephthalate textile bonded with oil modified alkyd resin varnish;

– enamels based on polyvinylformal, polyurethane or epoxy resins.

More extensive accelerated temperature tests and, in addition, compatibility testing is required for insulation systems of class B and higher temperature classes.

For totally enclosed motors using class A, E and B material, the temperatures may be increased by 5 K. A totally enclosed motor is a motor so constructed that the circulation of the air between the inside and the outside of the case is prevented but not necessarily sufficiently enclosed to be called airtight.

[c] To allow for the fact that the temperature of windings of universal motors, relays, solenoids, etc., is usually below the average at the points accessible to thermo-couples, the figures without square brackets apply when the resistance method is used and those with square brackets apply when thermocouples are used. For the windings of vibrator coils and a.c. motors, the figures without square brackets apply in both cases.

Table 13 *(3 of 3)*

d The value of the temperature rise of a copper winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

where

Δt is the temperature rise;

R_1 is the resistance at the beginning of the test;

R_2 is the resistance at the end of the test;

t_1 is the working ambient temperature at the beginning of the test, to be set at $\boldsymbol{T_{max}}$;

t_2 is the working ambient temperature at the end of the test;

At the beginning of the test, the windings are to be at $\boldsymbol{T_{max}}$.

It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

The maximum temperature attained for the purposes of Clause 14 is derived by adding the temperature rise to $\boldsymbol{T_{max}}$.

e For small windings with a cross section, the minor dimension of which is no greater than 5 mm, the maximum temperature permitted when measured by the resistance method is:

Class	°C
A	105
E	120
B	130
F	155
H	180

f For **controls** submitted in or on equipment, only the temperatures of terminals for fixed conductors are verified, as such equipment are not usually delivered with **external conductors**. For equipment with other than terminals for fixed conductors, the temperature of the insulation of the **external conductor** is determined instead of the temperature of the terminals.

Text deleted

g For incorporated and **integrated controls**, no temperature limit is applicable, but attention is drawn to the fact that most equipment standards limit the temperature of terminals of fixed appliances to 85 °C, which is the maximum allowable temperature for ordinary PVC cable insulation. The maximum temperature recorded should not exceed the value declared in Table 1, requirement 21.

When a **control** is incorporated/integrated into an appliance, the terminals for **external conductors** will, as part of the appliance, be subject to the specified tests of the appliance standard and assessed for compliance with the temperature limits of that standard.

h The temperature measured shall not exceed 85 °C unless a higher value has been declared by the manufacturer.

i The temperature values given, which are related to heat resistant properties of the material, may be exceeded where particular materials have been investigated and recognized as having special heat resistant properties.

j The values in square brackets apply to those parts of a material used for **actuating members**, handles, knobs, grips and the like and which are in contact with hot metal, but are not accessible.

k Where a metal part is in contact with a part made of insulating material it is assumed that the temperature of the insulating material at the point of contact is the same as the temperature of the metal part.

l The maximum permissible temperatures shall not exceed those which can be shown to be acceptable in service for these materials. The temperatures shall be recorded for the purposes of Clause 21.

m The maximum permissible temperature shall not exceed those which have been shown to be acceptable in service for these materials.

n Higher temperatures are acceptable for specific copper alloys if substantiated by test data from the alloy manufacturer to a recognized metallurgical standard. See also footnote m.

〖C〗**14.Z1** If the maximum permitted temperature of a winding or core lamination exceeds the value specified for the text described in 14.1, six additional samples shall be subjected to the following tests:

Moving parts, if any, are locked and a current is passed individually through each winding, this current being such that the temperature of the relevant winding is equal to the maximum temperature measured under the conditions specified in 14.1. This temperature is increased by whichever value is chosen from Table Z1. The total time during which the current is passed is as indicated in Table Z1 for the temperature increase chosen.

Table Z1

Temperature increase ºC (K)	**Total time** h
0 ± 3	p [a]
10 ± 3	0,5 p
20 ± 3	0,25 p
30 ± 3	0,125 p

[a] In general, p equals 8 000 for controls for EN 60335-1 applications.

The total time is divided into four equal periods, each of them being followed by a period of 48 h during which the control is subjected to a humidity treatment as specified in 12.2. After the final humidity treatment, the insulation shall withstand an electric strength test as specified in Clause 13, the test voltage for the electric strength being, however, reduced to 50 % of the values specified in the table of that clause.

Failure of only one of the six samples during the first of the four periods of the test is ignored.

If one of the six samples fails during the second, third or fourth period of the test, the remaining five samples are subjected to an additional fifth period of passing current and humidity treatment, followed by an electric strength and insulation resistance test as specified before.

Failure of any of the remaining five controls will entail a rejection.

The controls are then subjected to the test of 17.8, but only for half the number of cycles specified in that subclause. All controls shall then withstand an electric strength test as specified before.

EXAMPLES Examples of cases where there may be doubt with regard to the classification of the insulating system of a winding are those cases where well-known insulating materials are used in an unconventional way, where combinations of materials of different temperature classes are used at a temperature higher than that allowed for the lowest class used or where materials are used for which no sufficient experience is available, as may be the case for integral core insulation.

If it is desired to establish that the insulation system falls within the temperature class claimed by the manufacturer, the winding temperature shall be equal to the temperature limit for the class of insulation claimed, increased by the temperature increase chosen from Table Z1.

The temperature increase chosen from Table Z1 should be agreed with the manufacturer. 〖C〗

15 Manufacturing deviation and drift

15.1 Those parts of **controls** providing a **type 2 action** shall have adequate consistency of manufacture with regard to their declared **operating value**, **operating time**, or **operating sequence**.

〚C〛 *Text deleted* 〚C〛

15.2 *Compliance is checked by the appropriate tests of this clause.*

15.3 *For those **controls** which are completely or partially destroyed during their normal **operation**, the tests of the appropriate subclauses of Clause 17 are deemed to be sufficient.*

15.4 *For those **controls** which are dependent on the method of mounting on, or incorporation in an equipment for their **operation** the **manufacturing deviation** and the **drift** shall be declared separately and be comparative values. The declared **manufacturing deviation** should be expressed as a bandwidth or spread (for example, 10 K) and the **drift** by an alteration of value (for example, ±10 K or +5 K, –10 K).*

15.5 *The consistency shall be determined as follows:*

15.5.1 *Test apparatus used shall be such that the **control** is mounted in the manner declared by the manufacturer.*

15.5.2 *For **sensing controls**, the apparatus shall preferably be such that the normal **operation** of the **control** is used to **control** the apparatus.*

15.5.3 *However, because this test is made to determine comparative values rather than **response values**, the form of the apparatus is not critical. It should, however, simulate as nearly as is practicable the conditions of service.*

15.5.4 *The electrical conditions of the test shall normally be $V_{R\ max}$ and $I_{R\ max}$ unless different conditions have been declared in requirement 41 of Table 1.*

*However, the **operation** of the **control** shall be sensed by a suitable device with a sensing current not exceeding 0,05 A.*

15.5.5 *For **sensing controls**, the rate of change of **activating quantity** shall be any suitable value unless specific values have been declared in requirement 37 of Table 1.*

15.5.6 *The appropriate **operating value**, **operating time** or **operating sequence** shall be recorded for each sample. No two samples shall differ from each other by an amount exceeding the declared **manufacturing deviation**.*

15.5.7 *The recorded values are also used as reference values for each sample, so that the repeat tests after the environmental tests of Clause 16 and the endurance test of Clause 17 will enable **drift** to be determined.*

15.6 *For those **controls** which are not dependent for their **operation** on the method of mounting on, or incorporation in, an equipment (for example, **timers**, current **sensing controls**, voltage **sensing controls**, **energy regulators** or the drop-out current of **electrically operated controls**), the determination of consistency shall be as follows:*

15.6.1 *The **manufacturing deviation**, and/or the **drift** may be an absolute value. In this case, a single declaration combining both the **manufacturing deviation** and the **drift** may be made.*

15.6.2 *The appropriate **operating value**, **operating time** or **operating sequence** shall be initially measured for all samples and be within the limits declared by the manufacturer.*

15.6.3 *Test apparatus shall be such as to simulate the most arduous conditions of **normal use** declared.*

15.6.4 *If a **drift** value has been declared separately in requirement 42 of Table 1, the measured values for each sample shall be recorded as a reference value, so that the repeat tests after the environmental tests of Clause 16 and the endurance tests of Clause 17 will enable the **drift** to be determined.*

15.7 See Annex J.

15.8 See Annex J.

16 Environmental stress

16.1 Transportation and storage

Controls which are sensitive to the environmental stresses of temperature shall withstand the level of the appropriate stress likely to occur in transportation and storage.

16.1.1 *Compliance is checked by the appropriate tests of 16.2, carried out with the **control** being left in the same condition declared as a transportation condition. If no transportation condition is declared, the **control** is tested with an **actuating member** or **actuating means** in the most unfavourable position.*

16.2 Environmental stress of temperature

16.2.1 *The effect of temperature is tested as follows:*

– *The entire **control** shall be maintained at a temperature of (–10 ± 2) °C for a period of 24 h.* ▌C〉*See Annex ZB.*〈C▐

– *The entire **control** shall then be maintained at a temperature of (60 ± 5) °C for a period of 4 h.*

NOTE In Finland, Norway, and Sweden, different values of temperature and time may apply.

16.2.2 *The **control** is not energized during either test.*

16.2.3 *After each test, a **control** with an **actuating member** or **actuating means** shall be capable of being actuated to provide correctly the class of circuit disconnection declared, in so far as this can be determined without dismantling the **control**. This test is carried out at normal room temperature.*

*The **control** is held at room temperature for 8 h prior to **actuation**.*

16.2.4 *In addition, for **controls** with **type 2 actions**, the appropriate test of Clause 15 shall be repeated after each of the above tests. The value measured in these tests shall not differ from the value recorded in Clause 15 for the same sample, by an amount greater than the **drift** declared in requirement 42 of Table 1.*

17 Endurance

17.1 General requirements

17.1.1 **Controls**, including those submitted in or with an equipment, shall withstand the mechanical, electrical and thermal stresses that occur in **normal use**.

17.1.2 **Controls** with **type 2 actions** shall operate such that any **operating value**, **operating time** or **operating sequence** does not change by an amount greater than the declared **drift**.

17.1.2.1 *Compliance with 17.1.1 and 17.1.2 is checked by the tests of 17.1.3 as indicated in 17.16.*

17.1.3 Test sequence and conditions

〖C〗 NOTE For the test sequence and conditions of non-resettable thermal cut-outs, see 17.16. 〖C〗

17.1.3.1 *In general, the sequence of tests is:*

– *an ageing test specified in 17.6 (this test applies only to those actions classified as type 1.M or 2.M);*
– *an overvoltage test of **automatic action** at accelerated rate specified in 17.7.* 〖C〗 *Text deleted* 〖C〗
– *a test of **automatic action** at accelerated rate specified in 17.8;*
– *a test of **automatic action** at slow rate specified in 17.9 (this test applies only to **slow-make slow-break automatic actions**);*
– *an overvoltage test of **manual action** at accelerated speed specified in 17.10.* 〖C〗 *Text deleted* 〖C〗
– *a test of **manual action** at slow speed specified in 17.11;*
– *a test of **manual action** at high speed specified in 17.12 (this test applies only to actions with more than one pole, and where polarity reversal occurs during the **operation**);*
– *a test of **manual action** at accelerated speed specified in 17.13.*

17.1.3.2 *The electrical, thermal and mechanical conditions of test shall in general be those specified in 17.2, 17.3 and 17.4. The general test requirements are given in 17.6 to 17.14 inclusive. The particular test requirements are given in the appropriate part 2.*

17.1.3.3 *Tests for a **manual action** forming part of an **automatic action** are normally specified in the subclause appropriate to the **automatic action**. If, however, tests are not specified, then 17.10 to 17.13 inclusive apply to such **manual actions**.*

17.1.3.4 After all the tests specified the samples shall meet the requirements of 17.14, unless otherwise specified in the appropriate part 2.

17.1.4 See Annex H.

17.2 Electrical conditions for the tests

17.2.1 *Each circuit of the **control** shall be loaded according to the ratings declared by the manufacturer. Circuits and contacts which are not intended for external loads are operated with the designed load. Some changeover circuits may require testing separately for each part if such a manner has been declared by the manufacturer, particularly if the rating of one part of the changeover circuit depends upon the current carried by the other part.*

17.2.2 〔C〉*The electrical loads to be used are those specified in Table 14 at rated voltage V_R, with this voltage then being increased to 1,15 V_R for the overvoltage test of 17.7 and 17.10.*〈C〉

17.2.3 〔C〉 Void 〈C〉

17.2.3.1 〔C〉 Void 〈C〉

17.2.3.2 〔C〉 Void 〈C〉

17.2.4 *When there is an earthed neutral system, the enclosure shall be connected through a 3 A cartridge fuse to the* ***protective conductor*** *of the circuit, and for other than an earthed neutral system, the enclosure shall be connected through such a fuse to the live pole least likely to break down to earth.*

17.2.5 *For type 1.G or 2.G actions, or other off-load actions, auxiliary switches are used to simulate the intended* ***operation*** *during the test.*

Table 14 (17.2.1 of edition 3) – Electrical conditions for the overvoltage test

Text deleted

Type of circuit as classified in 6.2	Operation	AC circuit			DC circuit		
		V	A	Power factor (±0,05) [a]	V	A	Time constant (±1 ms)
Substantially resistive (classified 6.2.1)	Making and breaking	V_R	I_R	0,95	V_R	I_R	Non-inductive
Resistive or inductive (classified 6.2.2)	Making [b]	V_R	6,0 I_X or I_R if arithmetically the greater	0,6 0,95	V_R	2,5 I_X or I_R if arithmetically the greater	7,5
	Breaking	V_R	I_X or I_R if arithmetically the greater	0,95		I_X or I_R if arithmetically the greater	Non-inductive
Declared specific load [Za] (classified 6.2.3)	Making and breaking	V_R	As determined by load		V_R	As determined by load	
20 mA load (classified 6.2.4)	Making and breaking	V_R	20 mA	0,95	V_R	20 mA	Non-inductive
Declared motor load (classified 6.2.5)	Making and breaking	V_R	As declared		V_R	As declared	
Pilot duty load (classified 6.2.6)	Making [b]	V_R	10 VA/ V_R	0,35			
	Breaking	V_R	VA/ V_R	0,95			

[a] Resistors and inductors are not connected in parallel except that if any air-core inductor is used, a resistor taking approximately 1 % of the current through the inductor is connected in parallel with it. Iron-core inductors may be used provided that the current has a substantially sine waveform. For three-phase tests, three-core inductors are used.

[b] The specified making conditions are maintained for a period between 50 ms and 100 ms, and are then reduced by an auxiliary switch to the specified breaking conditions. If during any test to this clause, contact break occurs within 2 s of contact make, the conditions specified for making are also used for breaking.

[c] Void

[Za] For the tests of tungsten filament lamp load, the load and test of EN 60669-1:1999, 18.2 and for fluorescent lamp load the load of EN 60669-1:1999, 19.2 shall be used, under the conditions as specified in 17.16 in the relevant Part 2.

BS EN 60730-1:2016
IEC 60730-1:2013+AMD1:2015 CSV

17.3 Thermal conditions for the tests

17.3.1 *For parts of the **control** other than any temperature **sensing element**, the following shall apply:*

– *those parts which are accessible when the **control** is mounted in a declared manner shall be exposed to normal room temperature (see 4.1);*

– *the mounting surface of the control shall be maintained between $T_{s\ max}$, and either ($T_{s\ max}$ + 5) °C, or 1,05 times $T_{s\ max}$, whichever is greater;*

〈C〉 – *If T_{min} is less than 0 °C, the following additional tests shall be carried out with the **switch head** maintained between T_{min} and (T_{min} – 5) ° C:*

− *Controls with Type 1 action – Clauses 16 and 17;*

− *Controls with Type 2 action – Clauses 15, 16 and 17.*

Three additional samples required. 〈C〉

Additional samples will be required if tests have to be performed at both temperatures (T_{max} and T_{min}).

17.3.2 *During the tests of 17.8 and 17.13, the temperatures of 17.3.1 are applied for the last 50 % of each test. For the first 50 % of each test the **switch head** is maintained at normal room temperature.*

Additional samples will be required if tests have to be performed at both temperatures (T_{max} and T_{min}).

17.4 Manual and mechanical conditions for the tests

17.4.1 *For all **manual actions**, each cycle of **actuation** shall consist of a movement of the **actuating member** such that the **control** is successively moved into all positions appropriate to that action and then returned to its starting point; except that if a **control** has more than one intended **OFF position**, then each **manual action** shall be a movement from one **OFF position** to the next **OFF position**.*

17.4.2 *The speed of movement of the **actuating member** shall be:*

– *for slow speed:*

(9 ± 1)° per s for rotary actions;

(5 ± 0,5) mm/s for linear actions;

– *for high speed:*

*the **actuating member** shall be actuated by hand as fast as possible. If an **actuating member** is not supplied with a **control** then a suitable **actuating member** shall be fitted by the testing authority for the purpose of this test;*

– *for accelerated speed:*

(45 ± 5)° per s for rotary actions;

(25 ± 2,5) mm/s for linear actions.

17.4.3 *During the slow speed test of 17.4.2:*

*care is taken that the test apparatus drives the **actuating member** positively, without significant backlash between the apparatus and the **actuating member**.*

17.4.4 *During the accelerated speed test of 17.4.2:*

– *care is taken to determine that the test apparatus allows the **actuating member** to operate freely, so that it does not interfere with the normal action of the mechanism;*

– *for **controls** where the movement of the **actuating member** is limited:*

- *there shall be a dwell period of not less than 2 s at each reversal of direction;*
- *a torque (for rotary **controls**), or a force (for non-rotary **controls**) shall be applied at the extreme of each movement to verify the strength of the limiting end stops. The torque shall be either five times the normal actuating torque, or 1,0 Nm, whichever is the smaller, but with a minimum of 0,2 Nm. The force shall be either five times the normal actuating force, or 45 N, whichever is the smaller, but with a minimum of 9 N. If the normal actuating torque exceeds 1,0 Nm, or the normal actuating force exceeds 45 N, then the torque or force applied shall be the same as the normal actuating torque or force;*

– *for **controls** designed for a rotary **actuation** where the movement is not limited in either direction, three quarters of the number of cycles of **actuation** in each test shall be made in a clockwise direction, and one quarter in an anti-clockwise direction.*

– *for **controls** which are designed for **actuation** in one direction only, the test shall be in the designed direction, provided that it is not possible to rotate the **actuating member** in the reverse direction using the torques specified above.*

17.4.5 *Additional lubrication shall not be applied during these tests.*

17.5 Dielectric strength requirements

17.5.1 *After all the tests of this clause, the requirements of 13.2 shall apply, with the exception that the samples are not subjected to the humidity treatment before the application of the test voltage. The test voltages shall be 75 % of the corresponding test voltages shown in 13.2.*

〚C〉 *Text deleted* 〈C〛

17.6 Ageing test

17.6.1 *During this test, the **sensing element** shall be maintained at that value of the **activating quantity** determined and used in Clause 14. Other parts shall be maintained as specified in 17.3. **Controls** are electrically loaded as specified in 17.2 for the appropriate breaking condition. The duration of the test is (100 + 0,02 y) h where "y" is the value declared in 7.2. The test applies to **controls** with actions classified as type 1.M or 2.M.*

17.6.2 *If during this test, the action being tested operates, the value of the **activating quantity** is increased or decreased to cause reverse **operation** and then returned to a value differing by a quantity "x" from the original to enable the test to be resumed. This procedure may be repeated as many times as is necessary to complete the test, or until, when repeating the appropriate procedure of Clause 15, the **drift** limits declared in 7.2 are exceeded. The value of "x" is given in the appropriate part 2.*

17.7 Overvoltage test 〚C〉 *Text deleted* 〈C〛 of automatic action at accelerated rate

17.7.1 *The electrical conditions shall be those specified for overvoltage* 〚C〉 *Text deleted* 〈C〛 *in 17.2.*

17.7.2 *The thermal conditions shall be those specified in 17.3.*

17.7.3 *The method and rate of **operation** is:*

– *for **type 1 actions**, the rate of **operation** and the method of **operation** shall be agreed between the testing authority and the manufacturer;*

– *for **type 2 actions**, the method of **operation** shall be that intended by design. For type 2 sensing actions the rate of **operation** can be increased, either to the maximum cycling rate declared in Table 1, or so that the rates of change of **activating quantity** do not exceed α_2 and β_2 declared in the same subclause.*

NOTE 1 Examples of such methods are the replacement of the capillary of a hydraulic system with an air pressure device or the fitting of a **prime mover** of a different speed.

– *Type 2* ***controls*** *are tested at the most unfavourable* ***operating value*** *declared in Table 1, requirement 48.*

NOTE 2 For temperature and pressure operated **controls**, this is normally the maximum value.

17.7.4 *For type 2 sensing actions, overshoot at each* ***operation*** *shall be between the values declared in 7.2.*

17.7.5 *It is permissible in the case of sensing actions to increase the rates of change of* ***activating quantity****, or for other* ***type 1 actions*** *to override the* ***prime mover*** *between* ***operations****, provided that this does not significantly affect the results.*

17.7.6 *The number of automatic cycles for the test is either one tenth of the number declared in 7.2, or 200, whichever is the smaller.*

17.7.7 *During the test,* ***actuating members*** *are placed in their most unfavourable position.*

〚C〛 *Text deleted* 〚C〛

17.8 Test of automatic action at accelerated rate

17.8.1 *The electrical conditions shall be those specified in 17.2.*

17.8.2 *The thermal conditions shall be those specified in 17.3.*

17.8.3 *The method and rate of* ***operation*** *shall be as used during the test of 17.7.3.*

17.8.4 *The number of automatic cycles (except as shown below for* ***slow-make slow-break automatic actions****) shall be that declared in 7.2 less the number of cycles actually made during the test of 17.7. During the test,* ***actuating members*** *shall be placed in their most unfavourable position. During the test, the* ***failure*** *of any component part of a* ***type 1 action*** *which is not significant according to the requirements of the test, and which is considered to have failed as a result of the acceleration of the test, shall not be a cause of rejection, provided that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner, such that the total number of automatic cycles referred to in 7.2 can be completed.*

17.8.4.1 *For* ***slow-make slow-break automatic actions****, only 75 % of the number of automatic cycles referred to in 17.8.4 shall be carried out during this test. The remaining 25 % are carried out as specified in 17.9.*

〚C〛 *Text deleted* 〚C〛

17.9 Test of automatic action at slow rate

17.9.1 ***Slow-make slow-break automatic actions*** *shall be tested for the 25 % remainder of the number of automatic cycles specified in 17.8.*

17.9.2 *The electrical and thermal conditions shall be as specified in 17.2 and 17.3.*

17.9.3 *The method of* ***operation*** *is either by imposing a change of value of* ***activating quantity*** *on the* ***sensing element****, or by the* ***prime mover****. For* ***sensing controls****, the rates of change of* ***activating quantity*** *shall be α_1 and β_1 as declared in 7.2. It is permissible, in the case of a* ***sensing control*** *to increase the rates of change of* ***activating quantity****, or for other* ***automatic controls*** *to override the* ***prime mover****, between* ***operations****, provided that this does not significantly affect the results. For* ***sensing controls****, overshoot at each* ***operation*** *shall be between the values declared in 7.2. During this test for a* ***type 2 action****, continuous monitoring is essential to provide a record of* ***operating value****, overshoots or* ***operating sequences****.*

17.9.3.1 *Such monitoring is also recommended for other **controls** to determine consistency of testing.*

17.9.4 *If only the make or the break is a slow **automatic action**, then it may, by agreement between the testing authority and the manufacturer, be possible to accelerate the rest of the action, to which the details of 17.8 apply.*

17.10 Overvoltage test 〚C〛 *Text deleted* 〚C〛 of manual action at accelerated speed

17.10.1 *The electrical conditions shall be those specified for overvoltage 〚C〛 Text deleted 〚C〛 in 17.2.*

17.10.2 *The thermal conditions shall be those specified in 17.3.*

17.10.3 *The method of **operation** shall be that specified in 17.4 for accelerated speed. The number of cycles of **actuation** shall be either one tenth of the number declared in 7.2 or 100, whichever is smaller. During the test, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.*

〚C〛 *Text deleted* 〚C〛

17.11 Test of manual action at slow speed

17.11.1 *The electrical conditions shall be those specified in 17.2.*

17.11.2 *The thermal conditions shall be those specified in 17.3.*

17.11.3 *The method of **operation** shall be that specified in 17.4 for slow speed.*

17.11.4 *The number of cycles of **actuations** shall be either one tenth of the number declared in 7.2 or 100, whichever is smaller. During the test, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned, to ensure that **actuation** causes the appropriate **operation**.*

17.12 Test of manual action at high speed

NOTE This test applies only to actions which have more than one pole, and where polarity reversal occurs during the action.

17.12.1 *The electrical conditions are those specified in 17.2.*

17.12.2 *The thermal conditions are those specified in 17.3.*

17.12.3 *The method of **operation** is that specified in 17.4 for high speed.*

17.12.4 *The number of cycles of **actuation** is 100. During the tests, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.*

〚C〛 *Text deleted* 〚C〛

17.13 Test of manual action at accelerated speed

17.13.1 *The electrical conditions are those specified in 17.2.*

17.13.2 *The thermal conditions are those specified in 17.3.*

17.13.3 *The method of **operation** is that specified in 17.4 for accelerated speed.*

17.13.4 *The number of cycles of **actuation** is that number declared in 7.2 less the number actually made during the tests of 17.10, 17.11 and 17.12. During the test, **sensing elements** are maintained at a suitable value of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.*

17.13.5 *During the test, the **failure** of any component part of a **type 1 action** other than a **protective control** which is not significant according to the requirements of the test, shall not be a cause of rejection providing that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner such that the total required number of cycles of **actuation** can be completed.*

17.14 Evaluation of compliance

*After all the appropriate tests of 17.6 to 17.13 inclusive, modified as specified in the appropriate part 2, the **control** shall be deemed to comply if:*

- *all actions function automatically and manually in the intended and declared manner within the meaning of this standard;*
- *the requirements of Clause 14 with regard to those items designated by Footnote a of Table 13, that is, terminals, current-carrying parts and supporting surfaces, are still met;*
- *the requirements of Clause 8, 17.5 and Clause 20 are still met. For the tests of 17.5 and Clause 20, **controls** for which special samples were submitted for Clause 13, are tested at an appropriate condition to ensure that the contacts are open;*
- *for **type 2 actions**, the appropriate test of Clause 15 is repeated and the **operating value**, **operating time** or **operating sequence** shall still be within the value of **drift**, or within the values of combined **drift** and **manufacturing deviation**, whichever was declared;*
- *the circuit disconnection declared for each **manual action** can still be obtained;*
- *there is no evidence that any transient **fault** between **live parts** and earthed metal, accessible metal parts or **actuating members** has occurred.*

See also Annex H.

17.15 Void

17.16 Test for particular purpose controls

*The tests for particular purpose **controls** are specified in the appropriate Part 2s.*

17.17 to **17.18** See Annex J.

18 Mechanical strength

18.1 General requirements

18.1.1 **Controls** shall be so constructed as to withstand the mechanical stress that occurs in **normal use**.

18.1.2 **Actuating members** of **class I controls** and **class II control**, and **actuating members** of **controls** for class I and class II equipment, shall either have adequate mechanical strength or be such that adequate protection against electric shock is maintained if the **actuating member** is broken.

18.1.3 **Integrated controls** and **incorporated controls** are not tested as in 18.2 as their impact resistance will be tested by the equipment standard.

18.1.4 *Compliance is checked by the tests of the appropriate Subclauses 18.2 to 18.8 inclusive, carried out sequentially on one sample.*

18.1.5 *After the appropriate tests, the **control** shall show no damage to impair compliance with this standard and in particular with Clauses 8, 13, and 20. Insulating linings, barriers and the like shall not have worked loose.*

*It shall still be possible to remove and to replace detachable and other external parts such as **covers** without such parts or their insulating linings breaking.*

*It shall still be possible to actuate a **control** to any position which is intended to provide **full disconnection** and **micro-disconnection**.*

*In case of doubt, **supplementary insulation** or **reinforced insulation** is subject to an electric strength test as specified in Clause 13.*

*Damage to the finish, small dents which do not reduce **creepage distances** or **clearances** below the values specified in Clause 20, and small chips which do not adversely affect the protection against electric shock or moisture are neglected. Cracks not visible to the naked eye, and surface cracks in fibre reinforced mouldings and the like are ignored. If a decorative **cover** is backed by an inner **cover**, fracture of the decorative **cover** is neglected, if the inner **cover** withstands the test after removal of the decorative **cover**.*

18.1.6 In Canada and the USA, if threads for the connection of metal conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be any sharp edges, not less than three nor more than five full threads in the metal and the construction of the device shall be such that a suitable conduit bushing can be properly attached.

〚C〛 *Text deleted* 〚C〛

18.2 Impact resistance

18.2.1 ***In-line cord**, **free-standing** and **independently mounted controls*** 〚C〛 *Text deleted* 〚C〛 *are checked by applying blows to the sample by means of the apparatus in IEC 60068-2-75.*

18.2.2 *All surfaces which are accessible when the **control** is mounted as in **normal use** are tested with the apparatus.*

18.2.3 *The **control** is held in contact with a vertical sheet of plywood 8 mm thick and 175 mm square without any metallic back plate, the plywood being mounted on a rigid frame which is fixed to a solid wall of brick, concrete or the like.*

18.2.4 *Blows are applied to all **accessible surfaces**, including **actuating members**, at any angle, the test apparatus being calibrated to deliver an energy of (0,5 ± 0,04) Nm.*

18.2.4.1 *Foot actuated **controls** shall be subject to the same test, but using a test apparatus calibrated to deliver an energy of (1,0 ± 0,05) Nm.*

18.2.5 *For all such surfaces, three blows are applied to every point that is likely to be weak.*

18.2.5.1 *Care must be taken that the results from one series of three blows does not influence subsequent series.*

18.2.5.2 *If there is a doubt whether a defect has been caused by the application of preceding blows, this defect is neglected and the group of three blows which led to the defect is applied to the same place of a new sample, which shall then withstand the test.*

18.2.6 *Signal lamps and their **covers** are only tested if they protrude from the enclosure by more than 10 mm or if their area exceeds 4 cm², unless they form part of an **actuating member**, in which case they shall be tested in the same manner as an **actuating member**.*

18.3 〖C〗 Void 〖C〗

18.4 Alternate compliance – Impact resistance

〖C〗 *Text deleted* 〖C〗

〖C〗 *Text deleted* 〖C〗

〖C〗 *Text deleted* 〖C〗

18.5 Free-standing controls

18.5.1 ***Free-standing controls** shall be additionally checked by the test of 18.5.2 and 18.5.3 using the apparatus shown in Figure 4.*

18.5.2 *Two metres of flexible cord of the lightest type used in 10.1.4 shall be connected to the input terminals and secured as intended. **Controls** intended for use with a flexible cored connected to the output terminals shall have 2 m of the lightest intended type similarly connected and arranged as shown in Figure 4.*

The sample shall be stood or rested on the glass surface as shown and the cord shall be subjected to a steady pull gradually increasing up to, but not exceeding, that shown in Table 9. If the sample moves, it is pulled off the glass surface as slowly as possible and allowed to fall onto the concrete backed hard wood base.

*The height of the surface above the base is 0,5 m. The size of the hard wood and concrete base shall be sufficient for the **control** to remain on the base after falling.*

The test is repeated three times.

18.5.3 *After the test, the sample shall be evaluated as in 18.1.5.*

18.6 In-line cord controls

18.6.1 ***In-line cord controls** other than **free-standing controls** shall be additionally tested in a tumbling barrel as shown in Figure 5. The width of the barrel shall not be less than 200 mm, and shall be as wide as is necessary to ensure the uninterrupted fall of the **control** when fitted with the cords as required in 18.6.2.*

18.6.2 ***Controls** with **non-detachable cords** using **type X attachment** shall be fitted with the flexible cord or cords having the smallest cross-sectional area specified in 10.1.4 and a free length of approximately 50 mm. Terminal screws are tightened with two-thirds of the torque specified in 19.1. **Controls** with **non-detachable cords** using **type M attachment**, **type Y attachment** or **type Z attachment** shall be tested with cord or cords declared or supplied, the cord or cords being cut so that a free length of about 50 mm projects from the **control**.*

18.6.3 *The sample falls from a height of 50 cm onto a steel plate, 3 mm thick, the number of falls being:*

– *1 000 if the mass of the sample without cord does not exceed 100 g;*

– *500 if the mass of the sample without cord exceeds 100 g, but does not exceed 200 g.*

18.6.4 ***In-line cord controls*** *with a mass exceeding 200 g are not tested in the tumbling barrel, but shall be subjected to the test of 18.5.*

18.6.5 *The barrel is turned at a rate of five revolutions per min, 10 falls per min thus taking place.*

18.6.6 *After this test, the* ***control*** *shall be evaluated as in 18.1.5. Special attention is paid to the connection of flexible cord or cords.*

18.7 Pull-cord actuated controls

18.7.1 ***Pull-cord actuated controls*** *shall be additionally tested as in 18.7.2 and 18.7.3.*

18.7.2 *The* ***control*** *shall be mounted as declared by the manufacturer, and the* ***pull-cord*** *shall be subjected to a force, applied without jerks, first for 1 min in the normal direction, and then for 1 min in the most unfavourable direction, but not exceeding 45° from the normal direction.*

18.7.3 *The values of the force are shown in Table 19.*

Table 19 (18.7 of edition 3) – Pull-cord force test values

Rated current A	Force N	
	Normal direction	Most unfavourable direction
Up to and including 4	50	25
Over 4	100	50

18.7.4 *After this test, the* ***control*** *shall be evaluated as in 18.1.5.*

18.8 Foot actuated controls

18.8.1 ***Controls*** *actuated by foot shall be additionally tested as follows:*

18.8.2 *The* ***control*** *is subjected to a force applied by means of a circular steel pressure plate with a diameter of 50 mm. The force is increased continuously from an initial value of about 250 N, up to 750 N, within 1 min, after which it is maintained at this value for 1 min.*

18.8.3 *The* ***control*** *is placed on a flat horizontal steel support with the appropriate flexible cord fitted. The force is applied three times with the sample placed in different positions, the most unfavourable positions being chosen.*

18.8.4 *After the test, the* ***control*** *shall be evaluated as in 18.1.5.*

18.9 Actuating member and actuating means

18.9.1 *__Controls__ supplied with, or intended to be fitted with __actuating members__ shall be tested as follows.*

– *First an axial pull shall be applied for 1 min to try to pull off the __actuating member__.*

– *If the shape is such that it is not possible to apply an axial pull in __normal use__, this first test does not apply.*

– *If the shape of the __actuating member__ is such that an axial pull is unlikely to be applied in __normal use__, the force is 15 N.*

– *If the shape is such that an axial pull is likely to be applied, the force is 30 N.*

– *Secondly, an axial push of 30 N for 1 min is then applied to all __actuating members__.*

18.9.2 *If a __control__ is intended to have an __actuating member__ but is submitted for approval without, or is intended to have an easily removable __actuating member__ then a pull and push of 30 N are applied to the __actuating means__.*

NOTE Sealing compound and the like, other than self-hardening resins, is not deemed to be adequate to prevent loosening.

18.9.3 *During and after each of these tests, the __control__ shall show no damage, nor shall an __actuating member__ have moved so as to impair compliance with this standard.*

19 Threaded parts and connections

19.1 Threaded parts moved during mounting or servicing

19.1.1 Threaded parts, electrical or otherwise which are likely to be operated while the **control** is being mounted or during **servicing** shall withstand the mechanical stresses occurring in **normal use**.

NOTE Threaded parts which are operated while the **control** is being mounted, or during **servicing**, include items such as terminal screws, cord anchorage screws, fixing and mounting screws, nuts, threaded rings and **cover plate** screws.

19.1.2 Such parts shall be easily replaceable if completely removed.

NOTE Constructions which restrict the complete removal of a threaded part are deemed to meet this requirement.

19.1.3 Such threaded parts shall have a metric ISO thread or a thread of equivalent effectiveness.

NOTE Provisionally SI, BA and Unified threads are deemed to be of equivalent effectiveness to a metric ISO thread. A test for equivalent effectiveness is under consideration. Pending agreement to a test, all torque values for threads other than ISO, BA, SI or Unified are increased by 20 %.

19.1.4 If such a threaded part is a screw and if it generates a thread in another part, it shall not be of the thread cutting type. It may be of the thread forming (swaging) type. There is no requirement for the type of thread so produced.

19.1.5 Such screws may be of the space threaded type, (sheet metal) if they are provided with a suitable means to prevent loosening.

NOTE Suitable means to prevent loosening of space threaded screws include a spring nut, or other component of similar resilience, or a thread of resilient material.

19.1.6 Such threaded parts shall not be of non-metallic material if their replacement by a dimensionally similar metal screw could impair compliance with Clause 13 or 20.

19.1.7 Such 〚C〉 threaded parts 〈C〛 shall not be of metal which is soft or liable to creep such as zinc or aluminium.

This requirement is not applicable to parts used either as a **cover** to limit access to **setting** means, or as **setting** means such as flow or pressure adjusters in gas **controls**.

19.1.8 Such screws operating in a thread of non-metallic material shall be such that the correct introduction of the screw into its counterpart shall be ensured.

NOTE The requirement for the correct introduction of a metal screw into a thread of non-metallic material can be met if the introduction of the screw in a slanting manner is prevented, for example, by guiding the screw or part to be fixed by a recess in the female thread, or by the use of a screw with the leading thread removed.

19.1.9 Such threaded parts, when used for **in-line cord controls**, if they are transmitting contact pressure and if they have a nominal diameter less than 3 mm, shall screw into metal. If they are of non-metallic material, they shall have a nominal diameter of at least 3 mm, and shall not be used for any electrical connection.

19.1.10 *Compliance with 19.1.1 to 19.1.9 inclusive is checked by inspection and by the test of 19.1.11 to 19.1.15, inclusive.*

19.1.11 *Threaded parts are tightened and loosened:*

– *10 times if one of the threaded parts is of non-metallic material, or*

– *five times if both parts are of metallic material.*

19.1.12 *Screws in engagement with a thread of non-metallic material are completely removed and reinserted each time. When testing terminal screws and nuts, a conductor of the largest cross-sectional area used in 10.1.4 or of the minimum cross-sectional area specified in 10.2.1 is placed in the terminal.*

19.1.13 *The shape of the screwdriver should suit the head of the screw to be tested.*

19.1.14 *The conductor is moved each time the threaded part is loosened. During the test, no damage impairing the further use of the threaded parts shall occur, such as breakage of screws or damage to the slot head or washers.*

19.1.15 *The test is made by means of a suitable test screwdriver, spanner or key, applying a torque, without jerks, as shown in Table 20.*

Table 20 (19.1 of edition 3) – Threaded parts torque test values

Nominal diameter of thread mm	**Torque** Nm		
	I	**II**	**III**
Up to and including 1,7	0,1	0,2	0,2
Over 1,7 up to and including 2,2	0,15	0,3	0,3
Over 2,2 up to and including 2,8	0,2	0,4	0,4
Over 2,8 up to and including 3,0	0,25	0,5	0,5
Over 3,0 up to and including 3,2	0,3	0,6	0,6
Over 3,2 up to and including 3,6	0,4	0,8	0,6
Over 3,6 up to and including 4,1	0,7	1,2	0,6
Over 4,1 up to and including 4,7	0,8	1,8	0,9
Over 4,7 up to and including 5,3 [a]	0,8	2,0	1,0
Over 5,3 [a]	–	2,5	1,25

Use column I – for metal screws without heads if the screw when tightened does not protrude from the hole, or if the screwdriver access is limited to the major diameter of the screw.

Use column II – for other metal screws and for nuts:

- with a cylindrical head and a socket for a **special purpose tool**, the socket having a cross-corner dimension exceeding the overall thread diameter;
- with a head having a slot or slots, the length of which exceeds 1,5 times the overall thread diameter.

– for screws of non-metallic material having a hexagonal head with the dimension across flats exceeding the overall thread diameter.

Use column III – for other screws of non-metallic material.

[a] Nuts and threaded rings of greater than 4,7 mm in diameter which are used for single-bush mounting are tested with a torque of 1,8 Nm, except that, for **controls** for single-bush mounting using thermoplastic materials and where there is no torque effected on the mounting for **setting** or resetting (i.e. for **thermal cut-outs)**, the thread for mounting is tested with the maximum torque as declared by the manufacturer which in no case shall be less than 0,5 Nm.

19.2 Current-carrying connections

19.2.1 Current-carrying connections which are not disturbed during mounting or **servicing** and the efficiency or security of which is maintained by the pressure of a screw, threaded part, rivet or the like shall withstand the mechanical, thermal and electrical stresses occurring in **normal use**.

19.2.2 Such current-carrying connections which are also subject to torsion in **normal use**, (that is, having parts integral with or connected rigidly to **screw terminals**, etc.) shall be locked against any movement which could impair compliance with Clauses 13 or 20.

NOTE 1 The requirement regarding being locked against movement does not imply that the current-carrying connection shall be so designed that rotation or displacement is prevented, provided that any movement is appropriately limited and does not bring about non-compliance with this standard.

NOTE 2 Connections made with one screw, rivet or the like are sufficient if the parts are themselves prevented from making such movement by mechanical interaction between parts or by the provision of spring washers or the like.

NOTE 3 Connections made with one rivet with a non-circular or notched shank corresponding to appropriately shaped holes in the current-carrying parts are considered to meet this requirement. Connections made with two or more screws or rivets also meet this requirement.

NOTE 4 Sealing compound can be used if the parts so sealed are not subjected to stress during **normal use**.

19.2.3 Such current-carrying connections shall be so designed that contact pressure is not transmitted through non-metallic material other than ceramic or other non-metallic material having characteristics no less suitable, unless there is sufficient resilience in the corresponding metal parts to compensate for any shrinkage or distortion of the non-metallic material.

NOTE The suitability of non-metallic material is considered with respect to the stability of the dimensions within the temperature range applicable to the **control**.

19.2.4 Such current-carrying connections shall not make use of space threaded screws, unless the screws clamp the current-carrying parts directly in contact with each other, and are provided with a suitable means of locking.

19.2.4.1 Space threaded screws may be used to provide earthing continuity if at least two such screws are used for each connection.

〚C〛 *Text deleted* 〚C〛

19.2.5 Such current-carrying connections may make use of thread cutting screws if these produce a full-form standard machine screw thread.

19.2.5.1 Thread cutting screws may be used to provide earthing continuity if at least two such screws are used for each connection.

〚C〛 *Text deleted* 〚C〛

19.2.6 Such current-carrying connections, whose parts rely on pressure for their correct function, shall have resistance to corrosion over the area of contact not inferior to that of brass. This requirement does not apply to parts whose essential characteristics may be adversely affected by plating such as bimetallic blades, which if not plated shall be clamped into contact with parts which have adequate resistance to corrosion. Suitable corrosion resistance may be achieved by plating or a similar process.

19.2.7 *Compliance with 19.2.1 to 19.2.6 inclusive is checked by inspection. In addition, compliance with 19.2.3 and 19.2.6 is checked by an inspection of the metallic resilient parts after the tests of Clause 17 have been completed.*

20 Creepage distances, clearances and distances through solid insulation

Controls shall be constructed so that the **clearances**, **creepage distances** and distances through solid insulation are adequate to withstand the electrical stresses that can be expected.

Printed wiring boards conforming with all of the requirements for type 2 coating as specified in IEC 60664-3 shall comply with the minimum requirements of 20.3 for solid insulation. The spacing between the conductors before the protection is applied shall not be less than the values as specified in Table 1 of IEC 60664-3:2003. See also Annex Q.

Creepage distances and **clearances** between terminals for the connection of **external conductors** shall be not less than 2 mm, or the specified limit, whichever is the highest. This requirement does not apply to such terminals if they are only used for factory attachment of conductors or if they are used for connection in **ELV** circuits.

Creepage distances, **clearances** and distances through solid insulation in switch mode power supplies and other high frequency switching circuits where the fundamental frequency is above 30 kHz and less than 10 MHz shall be dimensioned in accordance with IEC 60664-4.

The tabulated values of Clause 20 are absolute minimum values that must be maintained for all manufacturing conditions and through the lifetime of the equipment.

Compliance is checked by inspection, by measurement and by the tests of this clause.

NOTE 1 The requirements and tests are based on IEC 60664-1 from which further information can be obtained.

NOTE 2 A **creepage distance** cannot be less than the associated **clearance**. The shortest **creepage distance** possible is equal to the required **clearance**.

NOTE 3 See Annex S for guidance.

20.1 Clearances

Clearances shall not be less than the values shown in Table 22 for case A, taking into account the **pollution degree** and the **rated impulse voltage** required to serve the overvoltage categories of Table 21, except that, for **basic insulation** and **functional insulation**, smaller distances may be used if the **control** meets the impulse 〖C〉 voltage 〈C〗 test of 20.1.12 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion or by movement of the parts (for example, during **operation** or during assembly), but in no case shall the **clearances** be less than the values for case B.

Compliance is checked by inspection, by measurement and, if necessary, by the test of 20.1.12.

NOTE 1 **Controls** normally are expected to comply with the requirements for the **overvoltage category** of equipment in which they are used unless special circumstances determine other categories to be appropriate. Annex L provides guidance.

NOTE 2 **Controls** which are constructed in accordance with the minimum dimensions of Table 22, for case A, need not be subjected to the impulse 〖C〉 voltage 〈C〗 test of 20.1.12. For further information on case A and case B, see 5.1.3.2 and 5.1.3.3 of IEC 60664-1:2007.

***Detachable parts** are removed. **Clearances** are measured with movable parts and parts such as hexagon nuts which can be assembled in different orientations placed in the most unfavourable position.*

*A force is applied to bare conductors and **accessible surfaces** in order to attempt to reduce **clearances** when making the measurement.*

The force is: 2 N for bare conductors;
*30 N for **accessible surfaces**.*

The force is applied by means of the test finger of Figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE **Clearances** are measured as specified in Annex B.

Table 21 (20.1 of edition 3) – Rated impulse voltage for equipment energized directly from the supply mains (from IEC 60664-1:2007, Table F.1)

Nominal voltage of the supply based on IEC 60038 [a] [b] V		**Voltage line-to-neutral derived from nominal voltages a.c. or d.c. up to and including** V	**Rated impulse voltage required according to overvoltage category** [c] V			
Three-phase four-wire systems [a]	**Single-phase** [d] **systems**		**I**	**II**	**III**	**IV**
		50	330	500	800	1 500
		100	500	800	1 500	2 500
	120/240	150	800	1 500	2 500	4 000
230/400 277/480		300	1 500	2 500	4 000	6 000
400/690		600	2 500	4 000	6 000	8 000

[a] The first value listed is the line-to-neutral or the line-to-earth voltage and the second value listed is the line-to-line voltage.

[b] For **controls** capable of generating an overvoltage at the **control** terminals, for example, switching devices, the **rated impulse voltage** implies that the **control** shall not generate overvoltage in excess of this value when used in accordance with the relevant standard and instructions of the manufacturer.

[c] See Annex L for an explanation of **overvoltage categories** and Annex M for application guidance. **Overvoltage category** may be specified in a part 2 or in the final equipment standard.

[d] See Annex K for other supply systems (for example, note that some three-phase, three-wire systems require higher **rated impulse voltage** than three-phase four-wire systems of similar voltage).

Table 22 (20.2 of edition 3) – Clearances for insulation co-ordination (from IEC 60664-1:2007, Table F.2)

Rated impulse voltage from Table 21 [a]	Clearances in air up to 2 000 m above sea-level [b] mm							
	Case A				Case B (impulse test required – see 20.1.12)			
	Pollution degree [c]				Pollution degree [c]			
kV	1	2	3	4	1	2	3	4
0,33	0,01	0,20	0,8	1,6	0,01	0,2	0,8	1,6
0,50	0,04				0,04			
0,80	0,10				0,1			
1,5	0,5	0,5			0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3

NOTE For small values of **clearances**, the uniformity of the electric field can deteriorate in the presence of **pollution**, making it necessary to increase the **clearance** values above the values of case B.

[a] For **functional insulation**, the **rated impulse voltage** is derived from the value in column 3 of Table 21 which covers the measured voltage across the **clearance**, unless otherwise declared and justified by the manufacturer. If the secondary winding of the stepdown transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the reference for the **rated impulse voltage** for the **clearances** of **basic insulation** on the secondary side shall be one step lower than that which covers the rated input voltage of the primary side of the transformer.

The use of an isolating transformer without an earthed protective screen does not allow a reduction in the **rated impulse voltage**.

[b] For altitudes of more than 2 000 m above sea-level, the values for **clearances** shall be multiplied with the correction factor specified in IEC 60664-1:2007, Table A.2.

[c] An explanation of **pollution degree** is given in Annex N.

20.1.1 The **clearances** of **basic insulation** shall be sufficient to withstand the overvoltages that can be expected in use, taking into account the **rated impulse voltage**. The values of Table 22, case A apply except as permitted by 20.1.7.

Compliance is checked by measurement.

20.1.1.1 If the **control** is supplied from a dedicated battery which has no provision for charging from an external mains supply, the **rated impulse voltage** shall be assumed to be 71 V peak.

20.1.2 For **functional insulation**, Table 22, case A applies

– except as permitted by 20.1.7;

or

– except that **clearances** for **electronic controls** are not specified if the requirements of H.27.1.1.3 are met with the **clearances** short-circuited.

20.1.3 *Compliance with 20.1 is checked by measurement using the methods of measurement as given in Annex B and Figure 17.*

20.1.3.1 *For **controls** provided with an equipment inlet or socket-outlet, the measurements are made twice, once with an appropriate connector or plug inserted, and once without a connector or plug inserted.*

20.1.3.2 *For terminals intended for the connection of **external conductors**, the measurements of such terminals are made twice, once with conductors of the largest cross-sectional area used in 10.1.4 fitted, and once without conductors fitted.*

20.1.3.3 *For terminals intended for the connection of **internal conductors**, the measurements of such terminals are made twice, once with conductors of the minimum cross-sectional area used in 10.2.1 fitted, and once without conductors fitted.*

20.1.4 *Distances through slots or openings in surfaces of insulating material are measured to metal foil in contact with the surface. The foil is pushed into corners and the like by means of the standard test finger shown in Figure 2, but is not pressed into openings.*

20.1.5 *The standard test finger is applied to apertures as specified in 8.1, the distance through insulation between **live parts** and the metal foil shall then not be reduced below the values specified.*

20.1.6 *If necessary, a force is applied to any point on bare **live parts** which are accessible before the **control** is mounted, and to the outside of surfaces which are accessible after the **control** is mounted, in an endeavour to reduce the **creepage distances**, **clearances** and distances through insulation while taking the measurements.*

20.1.6.1 *The force is applied by means of the standard test finger and has a value of:*

– *2 N for bare **live parts**;*

– *30 N for **accessible surfaces**.*

Compliance is checked by measurement and by test if necessary.

20.1.7 For **basic insulation** and **functional insulation**, smaller distances may be permitted if the **control** meets the impulse [C] voltage [C] test of 20.1.12 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion, by movement of the parts, or during assembly, but in no case shall the **clearances** be less than the values for case B.

Compliance is checked by the test of 20.1.12.

When testing **functional insulation**, the impulse voltage is applied across the **clearance**.

NOTE When carrying out the impulse [C] voltage [C] test, parts or components of the **control** can be disconnected if necessary.

[A1] **20.1.7.1** For **micro-disconnection** and **micro-interruption**, there is no specified minimum distance for the **clearance** between the contacts and between those current-carrying parts where the **clearance** varies with the movement of the contacts. [A1]

20.1.7.2 For **full disconnection**, the values specified in Table 22, case A apply to parts separated by the switching element including the contacts, when the contacts are in the fully open position.

20.1.8 **Clearances** of **supplementary insulation** shall be not less than those specified for **basic insulation** in Table 22, case A.

Compliance is checked by measurement.

20.1.9 Clearances of **reinforced insulation** shall be not less than those in Table 22, case A but using the next higher step for **rated impulse voltage** as a reference.

NOTE For **double insulation**, where there is no intermediate conductive part between the **basic insulation** and **supplementary insulation**, **clearances** are measured between **live parts** and the **accessible surface** or accessible metal parts. The insulation system is treated as **reinforced insulation**.

Compliance is checked by measurement.

20.1.10 For **controls** or portions of **controls** supplied from a transformer with **double insulation**, **clearances** of **functional insulation** and **basic insulation** on the secondary side are based on the secondary voltage of the transformer which is used as the nominal voltage of Table 21.

NOTE 1 The use of a transformer with separate windings alone does not allow a change of **overvoltage category**.

In the case of supply voltages derived from transformers without separate windings, the **rated impulse voltage** shall be determined from Table 21 based on the primary voltage for step-down transformers, and based on the maximum measured r.m.s. value of the secondary voltage for step-up transformers.

Part 2s may specify alternative criteria for some situations, for example, high voltage ignition sources.

Annex F, Table F.2 of IEC 60664-1:2007 gives **clearance** dimensions for higher impulse withstand voltages.

NOTE 2 See also references in Clause 24.

Compliance is checked by measurement or test if necessary.

20.1.11 For circuits having **ELV** levels which are derived from the supply by means of **protective impedance**, **clearances** of **functional insulation** are determined from Table 21 based on the maximum measured value of the **working voltage** in the **ELV** circuit.

20.1.12 The impulse voltage test, when required, is applied in accordance with 6.1.2.2.1 of IEC 60664-1:2007.

Part 2s may specify environmental test conditions.

*The impulse voltage is applied between **live parts** and metal parts separated by **basic insulation** or **functional insulation**.*

NOTE In the case of **functional insulation**, parts or components of the **control** can be disconnected if necessary.

20.1.13 If the secondary of a transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the **clearances** of **basic insulation** on the secondary side shall not be less than those specified in Table 22 but using the next lower step for **rated impulse voltage** as a reference.

NOTE The use of an isolating transformer without an earthed protective screen or earthed secondary does not allow a reduction in the **rated impulse voltage**.

For circuits supplied with a voltage lower than rated voltage, for example, on the secondary side of a transformer, **clearances** of **functional insulation** are based on the **working voltage**, which is used as the rated voltage for Table 21.

20.1.14 See Annex J.

20.1.15 See Annex H.

20.2 Creepage distances

20.2.1 **Controls** shall be constructed so that **creepage distances** for **basic insulation** are not less than those specified in Table 23 for the rated voltage, taking into account the material group and the **pollution degree**.

Creepage distances are not specified for **electronic controls** if the requirements of H.27.1.1.3 are met with the **creepage distance** short-circuited.

Compliance is checked by inspection and measurement.

***Detachable parts** are removed. **Creepage distances** are measured with movable parts and parts which can be assembled in different orientations placed in the most unfavourable position.*

*A force is applied to bare conductors and **accessible surfaces** in order to attempt to reduce **creepage distances** when making the measurement.*

The force is: 2 N for bare conductors;
*30 N for **accessible surfaces**.*

The force is applied by means of the test finger of Figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE **Creepage distances** are measured as specified in Annex B.

20.2.2 **Controls** shall be constructed so that **creepage distances** for **functional insulation** are not less than those specified in Table 24 for **working voltage**, taking into account the material group and the **pollution degree**.

Part 2s may specify alternative criteria for some situations, for example, high voltage ignition sources.

Compliance is checked by inspection and measurement.

***Detachable parts** are removed. **Creepage distances** are measured with movable parts and parts which can be assembled in different orientations placed in the most unfavourable position.*

*A force is applied to bare conductors and **accessible surfaces** in order to attempt to reduce **creepage distances** when making the measurement.*

The force is: 2 N for bare conductors;
*30 N for **accessible surfaces**.*

The force is applied by means of the test finger of Figure 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE 1 **Creepage distances** are measured as specified in Annex B.

NOTE 2 The relationship between material group and proof tracking index (PTI) values is found in 6.13.

The PTI values refer to values obtained in accordance with IEC 60112, and tested with solution A.

Materials, the PTI values of which have previously been found to comply with these material groups, are acceptable without further testing.

NOTE 3 For glass, ceramics, or other inorganic insulating materials which do not track, **creepage distances** need not be greater than their associated **clearance** for the purpose of insulation co-ordination.

Table 23 (20.3 of edition 3) – Minimum creepage distances for basic insulation

Rated voltage up to and including	**Creepage distances** [a] mm											
	Pollution degree											
	Printed wiring material [b] **Pollution degree**		**1**	**2**			**3**			**4**		
				Material group			**Material group**			**Material group**		
V	**1** [c]	**2** [d]		**I**	**II**	**III** [e]	**I**	**II**	**III** [e]	**I**	**II**	**III** [e]
50	0,025	0,04	0,2	0,6	0,9	1,2	1,5	1,7	1,9	2,0	2,5	3,2
125	0,16	0,25	0,3	0,8	1,1	1,5	1,9	2,1	2,4	2,5	3,2	4,0
250	0,56	1	0,6	1,3	1,8	2,5	3,2	3,6	4,0	5,0	6,3	8,0
400	1	2	1,0	2,0	2,8	4,0	5,0	5,6	6,3	8,0	10,0	12,5
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0	10,0	12,5	16,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9,0	10,0	12,5	16,0	20,0
800	2,4	4	2,4	4,0	5,6	8,0	10,0	11,0	12,5	16,0	20,0	25,0

[a] Lacquered conductors of windings are considered to be bare conductors but **creepage distances** are not required to be larger than the associated **clearance** specified in Table 22.

[b] When printed circuit boards are coated in accordance with Annex P or Clause Q.1 and the coating has a PTI of at least 175, the values specified for **pollution degree** 1 are permitted. The PTI shall be measured in accordance with IEC 60112.

[c] Material groups I, II, IIIa and IIIb.

[d] Material groups I, II and IIIa.

[e] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in **pollution degree** 4.

Compliance is checked by measurement.

Table 24 (20.4 of edition 3) – Minimum creepage distances for functional insulation

Working voltage r.m.s. [a] V	Creepage distances [b c] mm											
	Pollution degree											
	Printed wiring material [d] Pollution degree		1	2			3			4		
				Material group			Material group			Material group		
	1 [e]	2 [f]		I	II	III	I	II	III [g]	I	II	III [g]
10	0,025	0,04	0,08	0,40	0,40	0,40	1	1	1	1,6	1,6	1,6
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05	1,6	1,6	1,6
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25	1,7	1,7	1,7
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	21
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25

[a] For higher **working voltages**, the values of Table F.4 of IEC 60664-1:2007 apply.

[b] For glass, ceramics and other inorganic materials which do not track, **creepage distances** need not be greater than their associated **clearance**.

[c] There are no requirements across **micro-interruption** other than between terminals and **terminations**. Between terminals and **terminations**, the requirements are as specified in this table.

[d] When printed circuit boards are coated in accordance with Annex P or Clause Q.1 and the coating has a PTI of at least 175, the values specified for **pollution degree** 1 are permitted. The PTI shall be measured in accordance with IEC 60112.

[e] Material groups I, II, IIIa and IIIb.

[f] Material groups I, II and IIIa.

[g] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in **pollution degree** 4.

Compliance is checked by inspection.

20.2.3 Creepage distances of **supplementary insulation** shall be not less than those appropriate for **basic insulation** taking into account the material group and the **pollution degree**.

Compliance is checked by inspection and measurement.

20.2.4 Creepage distances of **reinforced insulation** shall be not less than double those appropriate for **basic insulation**, taking into account the material group and the **pollution degree**.

Compliance is checked by inspection and measurement.

20.2.5 See Annex J.

20.3 Solid insulation

Solid insulation shall be capable of durably withstanding electrical and mechanical stresses as well as thermal and environmental influences which may occur during the anticipated life of the equipment.

20.3.1 There is no dimensional requirement for the thickness of **basic insulation** or **functional insulation**.

20.3.2 The distance through insulation for **supplementary insulation** and **reinforced insulation**, for **working voltages** up to and including 300 V, between metal parts shall not be less than 0,7 mm.

NOTE This does not imply that the distance has to be through insulation only. The insulation can consist of solid material plus one or more air layers.

For **controls** having parts with **double insulation** where there is no metal between **basic insulation** and **supplementary insulation**, the measurements are made as though there is a metal foil between the two layers of insulation.

20.3.2.1 The requirement of 20.3.2 does not apply if the insulation is applied in thin sheet form, other than mica or similar scaly material.

– For **supplementary insulation**, it consists of at least two layers, provided that each of the layers withstands the electric strength test of 13.2 for **supplementary insulation**.
– For **reinforced insulation**, it consists of at least three layers, provided that any two layers together withstand the electric strength test of 13.2 for **reinforced insulation**.

Compliance is checked by inspection and by test.

20.3.2.2 The requirement of 20.3.2 does not apply if the **supplementary insulation** or the **reinforced insulation** is inaccessible and meets one of the following criteria.

– The maximum temperature determined during the tests of Clauses 27 and H.27 does not exceed the permissible value specified in Table 13.
– The insulation, after having been conditioned for 168 h in an oven maintained at a temperature equal to 25 K in excess of the maximum temperature determined during the tests of Clause 14, withstands the electric strength test of 13.2, this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

For optocouplers, the conditioning procedure is carried out at a temperature of 25 K in excess of the maximum temperature measured on the optocoupler during the tests of Clauses 14, 27 and H.27, the optocoupler being operated under the most unfavourable conditions which occur during these tests.

Compliance is checked by inspection and by test.

21 Resistance to heat, fire and tracking

21.1 General requirements

All non-metallic parts of a **control** shall be resistant to heat, fire and tracking.

*Compliance is checked by the tests of 21.2, except that **independently mounted controls** are checked by the tests of 21.3.*

No requirements exist for small parts as defined in 3.1 of IEC 60695-2-11:2000.

Text deleted

21.2 Integrated, incorporated and in-line cord controls

The following test sequences shall be conducted as appropriate to the position or function of the non-metallic part and the declared ball pressure and glow-wire test temperatures.

NOTE **Controls** can be used in widely different end applications. Selection of test levels from the requirements below can be influenced by consideration of the end-application standard's requirements.

21.2.1 *For parts which are accessible when the **control** is mounted in its manner of intended use, and the deterioration of which may result in the **control** becoming unsafe:*

– *ball pressure test 1 of G.5.1;*

– *the glow-wire test of Clause G.2 carried out at 550 °C.*

21.2.2 *For parts which retain in position current-carrying parts other than electrical connections:*

– *ball pressure test 2 of G.5.2;*

– *the glow-wire test of Clause G.2 carried out at 550 °C.*

NOTE The tests are not applicable to parts retaining in position current-carrying parts in low-power circuits as described in H.27.1.1.1

21.2.3 *For parts which maintain or retain in position electrical connections,*

– *ball pressure test 2 of G.5.2,*

*followed by the glow-wire test at the temperature appropriate for the application and as declared for the **control**:*

NOTE 1 See Annex F for further information.

Glow-wire test at 650 °C

– *the glow-wire test of Clause G.2 carried out at 650 °C.*

Glow-wire test at 750 °C

– *the glow-wire test of Clause G.2 carried out at 750 °C.*

Glow-wire test at 850 °C

– *the glow-wire test of Clause G.2 carried out at 850 °C.*

The tests are not applicable to parts retaining in position current-carrying parts in low-power circuits as described in H.27.1.1.1.

NOTE 2 **Controls** can be used in widely different end applications. Selection of test levels from the requirements below can be influenced by consideration of the end-application standard's requirements.

NOTE 3 For **controls** intended for incorporation into appliances within the scope of IEC 60335-1 parts within 3 mm of electrical connections can be evaluated as per 30.2 of that standard.

21.2.4 *For all other parts, (except decorative trim, knobs, etc.)*

– *the glow-wire test of Clause G.2 carried out at 550 °C.*

shall be carried out.

NOTE Unless otherwise indicated in a part 2, diaphragms, gaskets and sealing rings of glands are not subjected to the tests of 21.2.4.

21.2.5 Void

21.2.6 Void

21.2.7 Resistance to tracking

All non-metallic parts for which a **creepage distance** is specified in 20.2 shall have a resistance to tracking as declared.

NOTE 1 Required values of resistance to tracking are given either in the Part 2s of IEC 60730 or in the relevant equipment standard.

Controls designed for **operation** at **ELV** levels are not subjected to a tracking test.

NOTE 2 Within a **control**, different parts can have different PTI values appropriate to the **micro-environment** of the part.

〖C〗 *Compliance is checked by the tests of Clause G.4, carried out at a voltage corresponding to the PTI value declared for Table 1, requirement 30.* 〖C〗

– *100 V;*
– *175 V;*
– *250 V;*
– *400 V;*
– *600 V.*

NOTE 3 For the purposes of 21.2.7, the proximity of arcing contacts is not considered to increase the deposition of external conductive material as the endurance tests of Clause 17, followed by the electric strength tests of Clause 13, are deemed sufficient to determine the effect of **pollution** arising from within the **control**.

21.3 Independently mounted controls

The test sequence of 21.2.1 through 21.2.7 applies, preceded by the preconditioning of 21.3.1.

〖C〗 For parts that maintain or retain in position electrical connections, the glow-wire test shall be carried out at a temperature of 850 °C. 〖C〗

21.3.1 Preconditioning

Preconditioning shall be carried out in a heating cabinet as follows:

– *without T rating: 1 × 24 h at (80 ± 2) °C, the circuit of the switching part and the driving mechanism not being connected, with detachable **covers** removed;*
– *with T rating for temperatures not exceeding 85 °C: 1 × 24 h at (80 ± 2) °C, the switching part of the **control** and the driving mechanism not being connected and without **covers** and subsequently 6 × 24 h at (T_{max} ± 2) K with **covers**, with the circuit of the switching part and driving mechanism being connected;*
– *with T rating for temperatures exceeding 85 °C: 6 × 24 h at (T_{max} ± 2) K with **covers**, with the circuit of the switching part and driving mechanism being connected.*

〈C〉 *Text deleted* 〈C〉

22 Resistance to corrosion

22.1 Resistance to rusting

22.1.1 Ferrous parts, including **covers** and enclosures, the corrosion of which might impair compliance with this standard, shall be protected against corrosion.

22.1.2 This requirement does not apply to temperature **sensing elements** or to other component parts whose performance would be adversely affected by protective treatment.

22.1.3 *Compliance is checked by the following test:*

22.1.4 *The parts are subjected to a test of 14 days duration at 93 % to 97 % relative humidity at (40 ± 2) °C.*

22.1.5 *After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surfaces shall show no corrosion which might impair compliance with Clauses 8, 13, and 20.*

22.1.6 *Traces of rust on sharp edges and a yellowish film removable by rubbing are ignored.*

NOTE 1 Parts protected by enamelling, galvanizing, sherardizing, plating or other recognized equivalent protection are deemed to meet this requirement.

NOTE 2 For small helical springs and the like, and for parts exposed to abrasion, a layer of grease can provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film, and the test is then made without removal of the grease.

23 Electromagnetic compatibility (EMC) requirements – Emission

See also Clause H.23.

23.1 **Free-standing** and **independently mounted controls**, which cycle during normal **operation**, shall be so constructed that they do not generate excessive radio interference. **Integrated** and **incorporated controls** are not subjected to the tests of 23.1, as the result of these tests can be affected by the incorporation of the **control** in equipment. They may, however, be carried out on such **controls** if requested by the manufacturer.

Equipment that uses integrated or **incorporated controls** should comply with its relevant product EMC standard. **Integrated** and **incorporated controls** are tested in the end use equipment.

[C] *Compliance is checked by one of the following methods as declared by the manufacturer (Table 1, requirement Z1) (see also Table H.10).* [C]

a) Testing in accordance with CISPR 14-1, with the following modification and/or CISPR 22, class B. In 4.2.3.3 of CISPR 14-1:2005, the value of 200 ms is replaced by 20 ms.

*b) Testing as detailed in 23.1.1 and 23.1.2, resulting in a maximum duration of radio frequency emission of 20 ms. Where such **controls** have a click rate greater than 5, method a) shall be followed.*

*c) Examination and/or tests to show that the minimum time between contact **operations** during normal **operation** cannot be less than 10 min.*

Compliance with method b) or c) shows compliance with method a).

23.1.1 Test conditions

[A1] *One previously untested sample is subjected to the test.* [A1]

The electrical and thermal conditions are as specified in 17.2 and 17.3, except as follows:

[C] – *the test is conducted at the lowest declared voltage and lowest declared current (Table 1, requirement Z2);* [C]

– *for **sensing controls**, the rate of change of activating quantities is α_1 and β_1;*

– *for non-**sensing controls**, the **controls** are caused to operate at the lowest contact operating speed possible during normal **operation**;*

– *for **controls** declared for use with inductive loads, the power factor is 0,6, unless declared otherwise in Table 1, requirement 7. For **controls** declared with purely resistive loads, the power factor is 1,0.*

23.1.2 Test procedure

*The **control** is operated for five **cycles of contact operation**.*

[C] *The duration of radio interference is measured by an oscilloscope, or the measuring equipment specified in EN 55016-1-1 but with the capability to measure 20 ms, connected to the control so as to measure the voltage drop across the contacts.* [C]

NOTE For the purpose of this test, radio interference is any observed fluctuation of voltage across the contacts which is superimposed on the supply waveform as a result of contact **operation**.

23.2 Controls for ISM (Industrial, Scientific and Medical) equipment and free-standing, independently mounted and **in-line cord controls** for use with ISM equipments shall comply with the requirements of CISPR 11.

NOTE See also Table 1, requirement 89.

24 Components

24.1 Transformers intended to supply power to a **SELV**-circuit or PELV-circuit shall be of the safety isolating type and shall comply with the relevant requirements of IEC 61558-2-6.

[A1] Capacitors connected between two line conductors or between a line conductor and the neutral or between **hazardous live parts** and protective earth shall be in accordance with IEC 60384-14 and shall be used in accordance with its rated values.[A1]

Fuses shall comply with the requirements of IEC 60127-1 or IEC 60269-1, as appropriate.

24.1.1 **Controls** that incorporate a transformer as the source of supply to a **SELV**-circuit or PELV-circuit are subjected to an output test with the primary energized at the upper limit of the rated voltage as indicated in 17.2.2 [C] *Text deleted* [C].

Switch mode power supplies or transformers used in converters shall comply with the requirements of IEC 61558-2-16.

Under any non-capacitive conditions of loading (from no load to the short-circuiting of any or all secondary **SELV**- or PELV-circuit terminals) and without disturbing internal connections, the secondary output voltage shall not be greater than that defined in 2.1.5.

If a converter or switch mode power supply is used as the source of supply to a **SELV**-circuit or PELV-circuit, Clause T.3 applies.

The secondary output power at the terminals to an **isolated limited secondary circuit** shall not exceed 100 VA and the secondary output current shall not exceed 8 A after 1 min of **operation** with overcurrent protection, if provided, bypassed.

24.2 Components other than those detailed in 24.1 are checked when carrying out the tests of this standard.

24.2.1 However, for components which have previously been found to comply with a relevant IEC safety standard, to reduce the testing necessary, assessment is limited to the following:

a) the application of the component within the **control** is checked to ensure that it is covered by previous testing to the IEC safety standard;
b) testing according to this standard of any conditions not covered by the previous testing to the IEC safety standard.

See also Annex J.

24.3 Annex U is not applicable to relays used as components in a **control**.

24.4 Switch mode power supplies not covered by 24.2.1, including their peripheral circuitry, used in **electronic controls** shall comply with the tests of 24.4.1 and all of the applicable requirements of this standard.

NOTE Subclause 24.4.1.11 gives the compliance criteria for the tests.

24.4.1 Overload tests for switch mode power supplies

24.4.1.1 *Each output winding, or section of a tapped winding, is overloaded in turn, one at a time, while the other windings are kept loaded or unloaded, whichever load conditions of* ***normal use*** *is the least favourable.*

24.4.1.2 *The overload is carried out by connecting a variable resistor (or an electronic load) across the winding or the rectified output. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No further readjustments are then permitted.*

24.4.1.3 *For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc. are allowed to remain in the circuit.*

24.4.1.4 *If overcurrent protection is provided by a current-breaking device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 h. If this value cannot be derived from the specification, it is to be established by test.*

24.4.1.5 *If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.*

24.4.1.6 *In case of voltage foldback, the overload is slowly increased to the point which causes the output voltage to drop by 5 %. The overload is then established at the point where the output voltage recovers and held for the duration of the test.*

24.4.1.7 *The duration of the test is to be for 1 h or until ultimate results are reached.*

24.4.1.8 *The maximum open-circuit voltage of each winding (directly at the winding of the transformer) and the maximum load current are measured and recorded such that the maximum output power may be determined.*

24.4.1.9 *The maximum open circuit voltage measurements shall be made during normal* ***operation*** *and under single component* ***failure****, see Table H.24.*

24.4.1.10 *For* ***SELV*** *applications, where the maximum open circuit voltage measured directly at the secondary of the transformer exceeds the limits specified in 2.1.5, the measurement of the maximum output voltage of each winding may be made after certain* ***protective impedances****. In this case, the limits shall be in accordance with H.8.1.10.1.*

24.4.1.11 *Following each test (while still in a heated condition), the transformer is to be subjected to the electric strength test of 13.2.*

24.4.1.12 *Compliance shall be in accordance with items a), b), c), d), e) and f) of H.27.1.1.3.*

24.5 Annex J is not applicable to **thermistors** used in a circuit which meets all of the following requirements:

– type 1 **control** as declared in Table 1, requirement 39;
– connected to a **SELV**/PELV circuit as specified in Clause T.1;
– low power circuit as specified in H.27.1.1.1;
– the **control** or final equipment complies with Clause H.27 when the **thermistor** is open or short circuited;
– **control** with **class A control functions** as declared in Table 1, requirement 92.

25 Normal operation

[A1] 25.1 General [A1]

See Annex H.

[A1] 25.2 Overvoltage and undervoltage test

A **control** incorporating an electro-magnet shall operate as intended at any voltage within the range of 85 % of the minimum rated voltage and 110 % of the maximum rated voltage, inclusive.

*Compliance is checked by subjecting the **control** to the following tests at the maximum and minimum operating conditions declared, except that only a **control** having T_{min} less than 0 °C is tested at T_{min}:*

*The **control** is subjected to 1,1 $V_{R\ max}$ until equilibrium temperature is reached and then tested immediately for **operation** at 1,1 $V_{R\ max}$ and at rated voltage.*

*The **control** is also subjected to 0,85 $V_{R\ min}$ until equilibrium temperature is reached and then tested immediately for **operation** at 0,85 $V_{R\ min}$.* [A1]

26 Electromagnetic compatibility (EMC) requirements – Immunity

See Clause H.26.

NOTE In general, the tests of Clause H.26 are not applicable to non-electronic **controls** because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic **controls** are typically included in other clauses of the appropriate part 2.

27 Abnormal operation

27.1 See Annex H and Annex J.

27.2 [C] Locked mechanism test [C]

Controls incorporating electro-magnets shall withstand the effects of blocking of the **control** mechanism.

Compliance is checked by the tests of 27.2.1 and 27.2.2.

NOTE For relays and contactors, compliance with this requirement is established by successful completion of the tests of Clause 17.

27.2.1 *The **control** mechanism is blocked in the position assumed when the **control** is de-energized. The **control** is then energized at rated frequency and rated voltage as indicated in 17.2.2* [C] *Text deleted* [C].

The duration of the test is either 7 h; or until an internal protective device, if any, operates; or until burnout, whichever occurs first.

27.2.2 *After this test, the **control** shall be deemed to comply if:*

– *there has been no emission of flame or molten metal, and there is no evidence of damage to the **control** which would impair compliance with this standard;*

– *the requirements of 13.2 are still met.*

NOTE The **control** need not be operative following the test.

27.2.3 Blocked mechanical output test (abnormal temperature test)

Controls with motors, such as electric actuators, shall withstand the effects of blocked output without exceeding the temperatures indicated in Table 26. Temperatures are measured by the method specified in 14.7.1. This test is not conducted on **controls** with motors, such as electric actuators, where, when tested under blocked output conditions for 7 h, any protective device, if provided, does not cycle under stalled conditions, and which do not exceed temperature limits in Table 13.

27.2.3.1 ***Controls*** *with motors, such as electric actuators, are tested for 24 h with the output blocked at rated voltage and in a room temperature in the range of 15 °C to 30 °C, the resulting measured temperature being corrected to a 25 °C reference value.*

〖C〗 *Text deleted* 〈C〉

For **controls** with motors declared for three-phase **operation**, the test is to be carried out with any one phase disconnected.

Table 26 (27.2.3 of edition 3) – Maximum winding temperature (for test of mechanical blocked output conditions)

Condition	Temperature of insulation by class °C							
	A	E	B	F	H	200	220	250
If impedance protected:	150	165	175	190	210	230	250	280
If protected by protective devices:								
During first hour – maximum value	200	215	225	240	260	280	300	330
After first hour								
– maximum value	175	190	200	215	235	255	275	305
– arithmetic average	150	165	175	190	210	230	250	280

27.2.3.2 The average temperature shall be within the limits during both the second and the twenty-fourth hours of the test.

NOTE The average temperature of a winding is the arithmetic average of the maximum and minimum values of the winding temperature during the 1 h period.

27.2.3.3 During the test, power shall be continually supplied to the motor.

27.2.3.4 Immediately upon completion of the test, the motor shall be capable of withstanding the electric strength test specified in Clause 13, without first applying the humidity treatment of 12.2.

27.3 Overvoltage and undervoltage test

〖A1〗 Void. 〈A1〉

27.4 See Annex H.

27.5 Overload tests

27.5.1 General

The tests are conducted as follows.

– ***Controls*** *as specified without protective devices and without incorporated fuses are loaded for 1 h with the conventional tripping current for the fuse which in the installation will protect the* ***control****.*

– ***Controls*** *protected by protective devices (including fuses) are loaded in such a way that the current through the* ***control*** *is 0,95 times the current with which the protective device releases after 1 h. The temperature rise is measured after a steady state has been reached or after 4 h, whichever is the shorter time.*

– ***Controls*** *protected by incorporated fuses complying with IEC 60127-1 shall have those fuses replaced by links of negligible impedance and shall be loaded in such a manner that the current through the links shall be 2,1 times the rated current of the fuse. The temperature rise is measured after the* ***control*** *has been loaded for 30 min. The value 2,1 times can be de-rated by 0,5 %/K, if the overload test is carried out at a higher temperature compared to normal room temperature.*

– ***Controls*** *protected both by incorporated fuses and by protective devices are loaded either as described above with incorporated fuses or with another protective device, choosing the test requiring the lower load.*

– ***Controls*** *protected by protective devices which will short-circuit only in case of overload shall be tested both as* ***controls*** *with protective devices and as* ***controls*** *without protective devices.*

27.5.2 Overload tests carried out on in-line cord controls as indicated in 11.10.2 and provided with a plug and socket outlet

The tests according to 27.5.1 shall be carried out.

The temperature shall not exceed those indicated in Table 13.

27.5.3 For controls not covered by 27.5.2

The tests according to 27.5.1 shall be carried out at ambient temperature (20 ± 5) °C. If declared in requirement 97 of Table 1, the test will not be done for ***incorporated controls*** *and* ***integrated controls****.*

The compliance with items a) to g) of H.27.1.1.3, where applicable, is verified.

27.6 Battery short-circuit test

For ***controls*** *having batteries that can be removed without the aid of a* ***tool*** *and having terminals that can be short-circuited by a thin straight bar, the terminals of the battery are short-circuited with the battery being fully charged.*

The duration of the test is either 1 h or until ultimate condition exists, whichever occurs first.

27.6.1 *After this test, the* ***control*** *shall be deemed to comply if:*

– *there has been no emission of flame or molten metal, and there is no evidence of damage to the* ***control*** *which would impair compliance with this standard;*

– *the requirements of 13.2 are still met.*

NOTE The **control** need not be operative following the test.

28 Guidance on the use of electronic disconnection

See Annex H.

Dimensions in millimetres

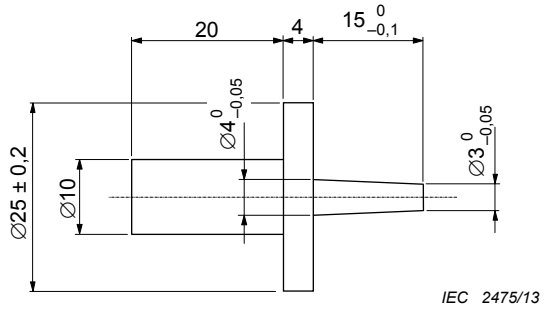
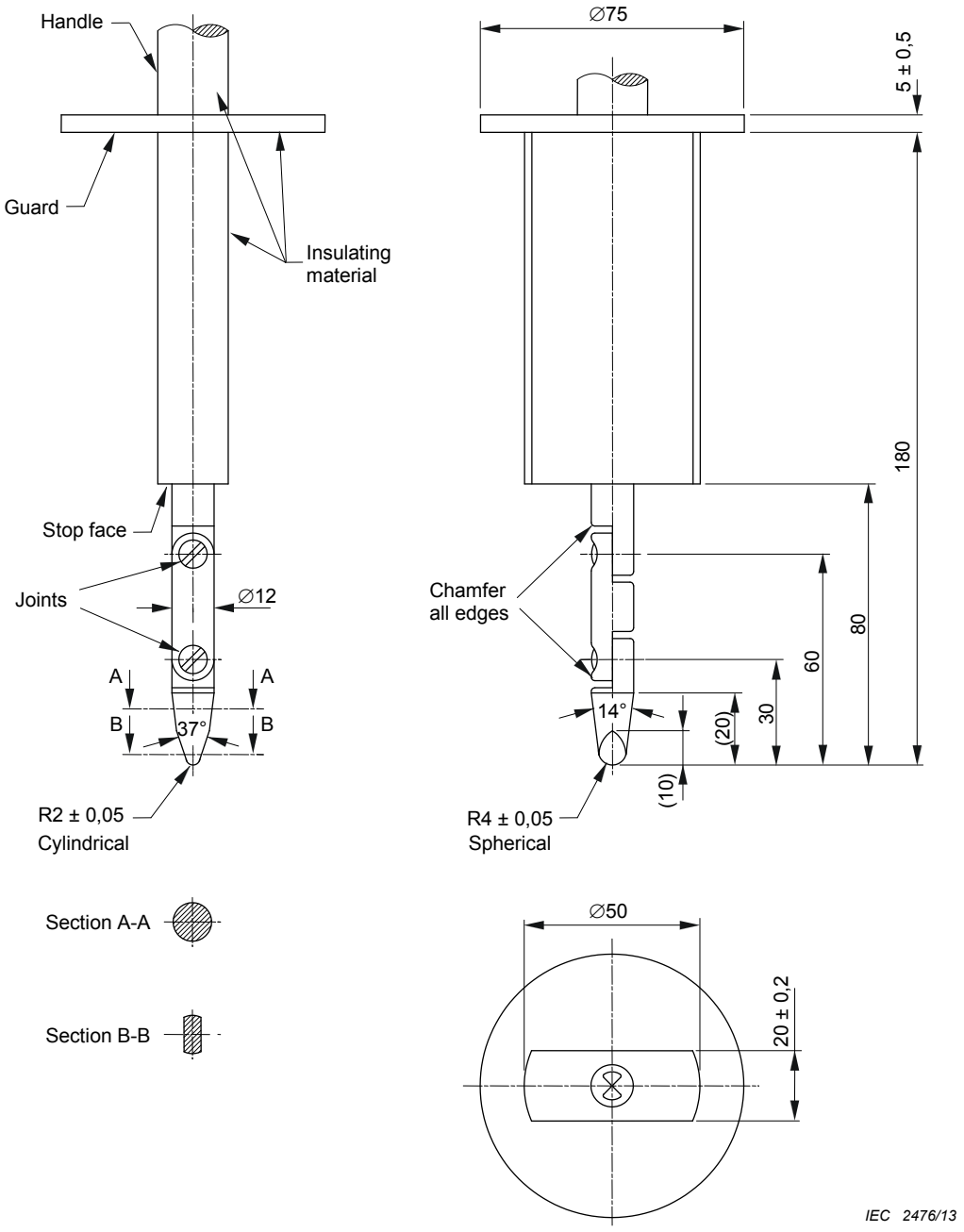


Figure 1 – Test pin

Linear dimensions in millimetres



Tolerances on dimensions without specific tolerance:

on angles $^{0}_{-10}$ °

on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$

over 25 mm: ±0,2

Material of finger: for example, heat-treated steel.

Both joints of this finger may be bent through an angle of 90° but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design must ensure a 90° bending angle with a 0° to 10° tolerance.

Figure 2 – Standard test finger

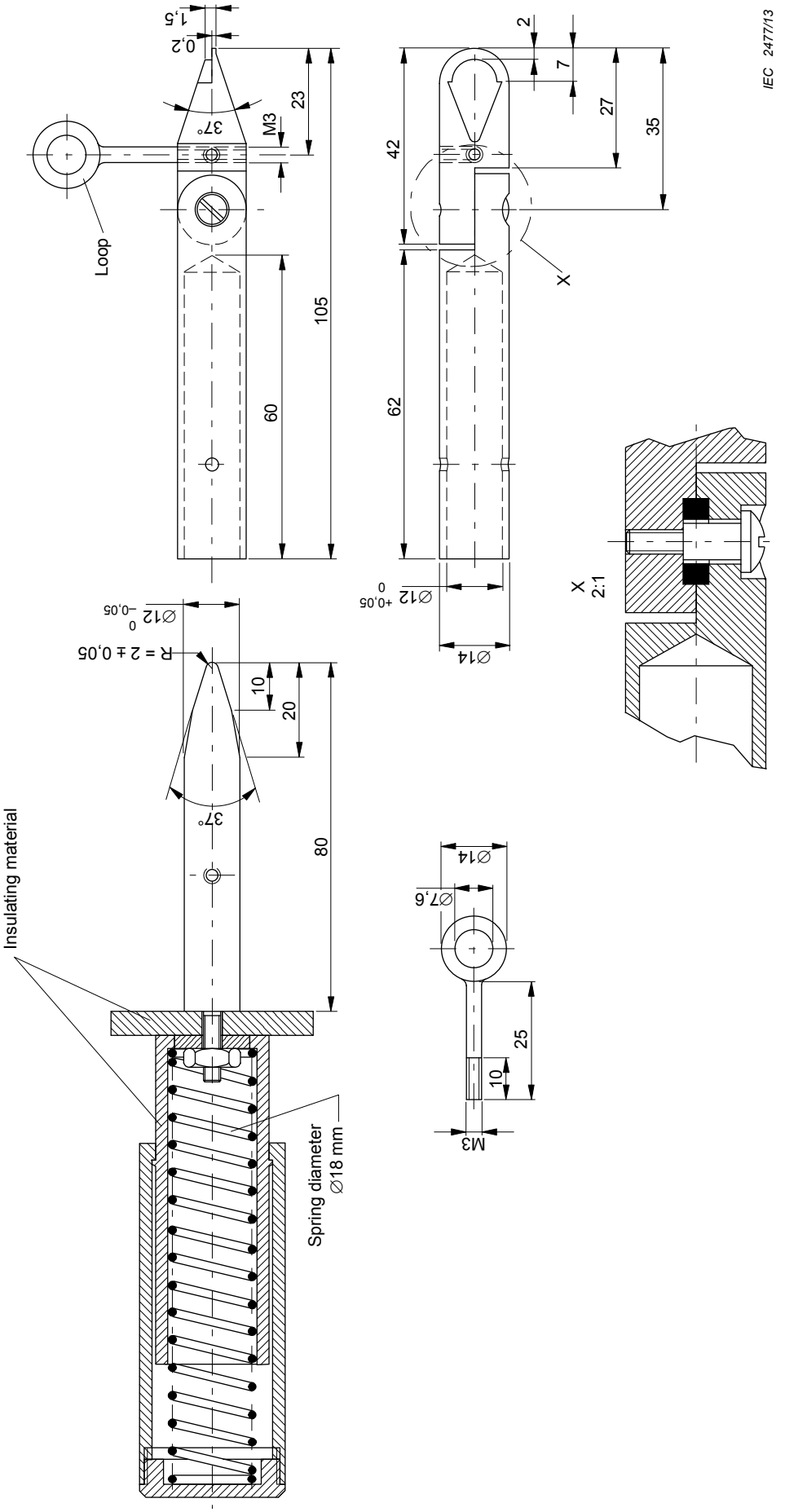


Figure 3 – Test nail

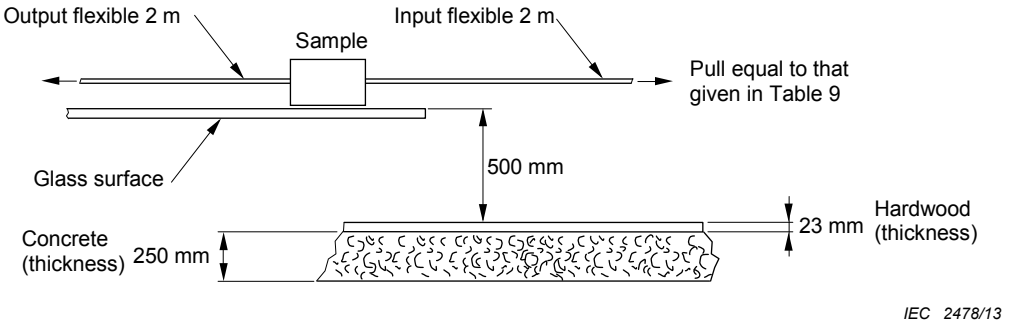


Figure 4 – Impact test for free-standing controls

Dimensions in millimetres

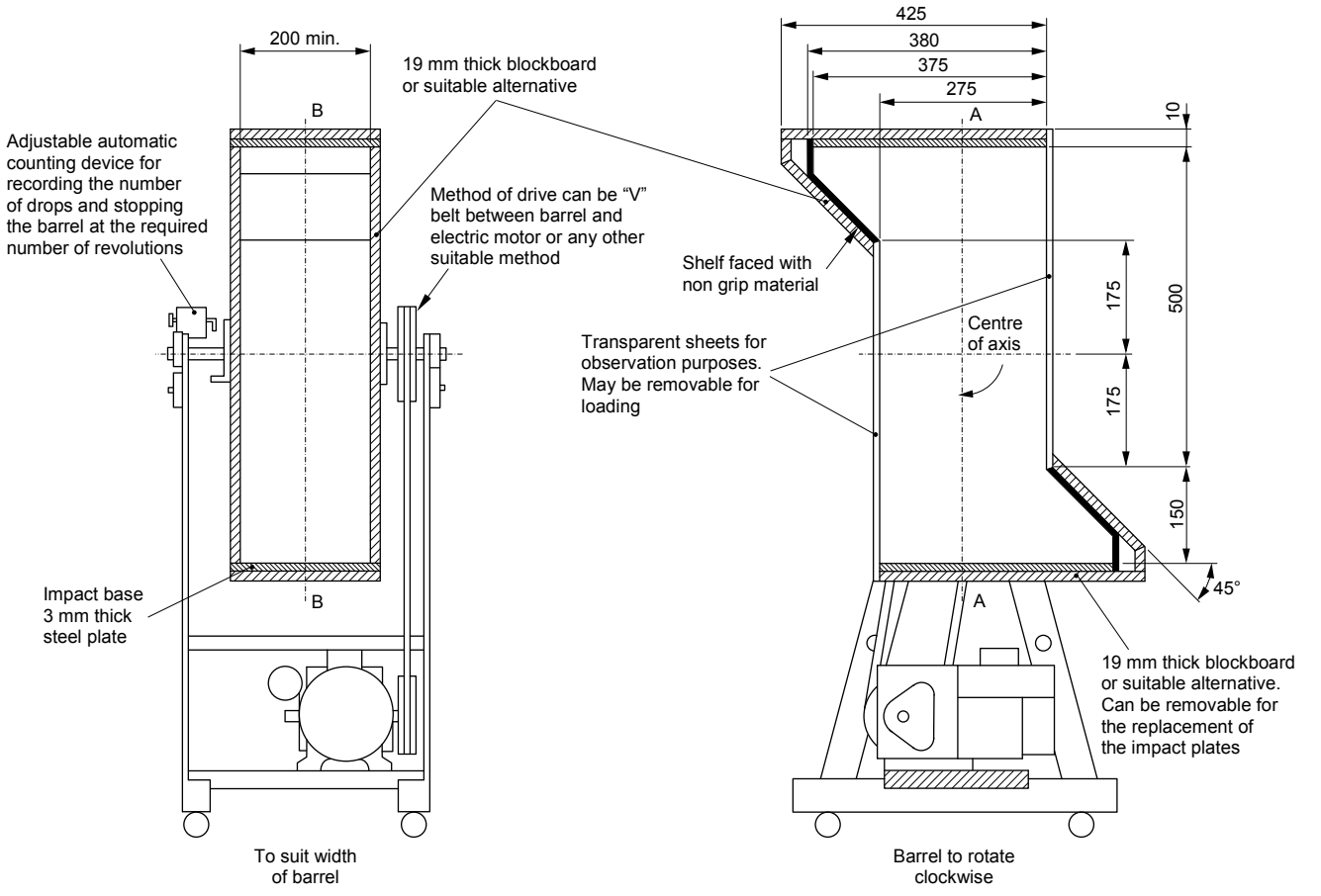


Figure 5 – Tumbling barrel

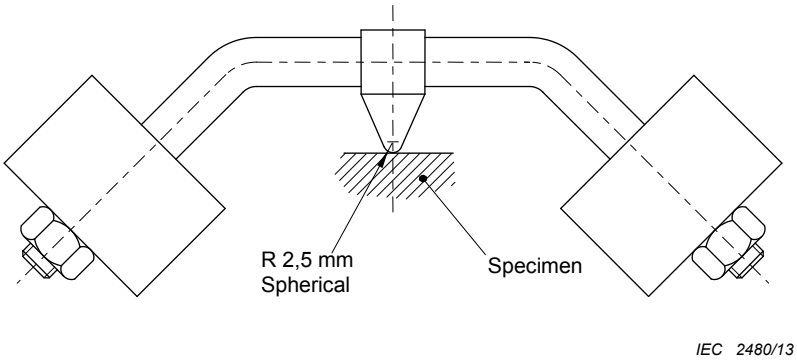


Figure 6 – Ball-pressure apparatus

Figure 7 – Void

Dimensions in millimetres

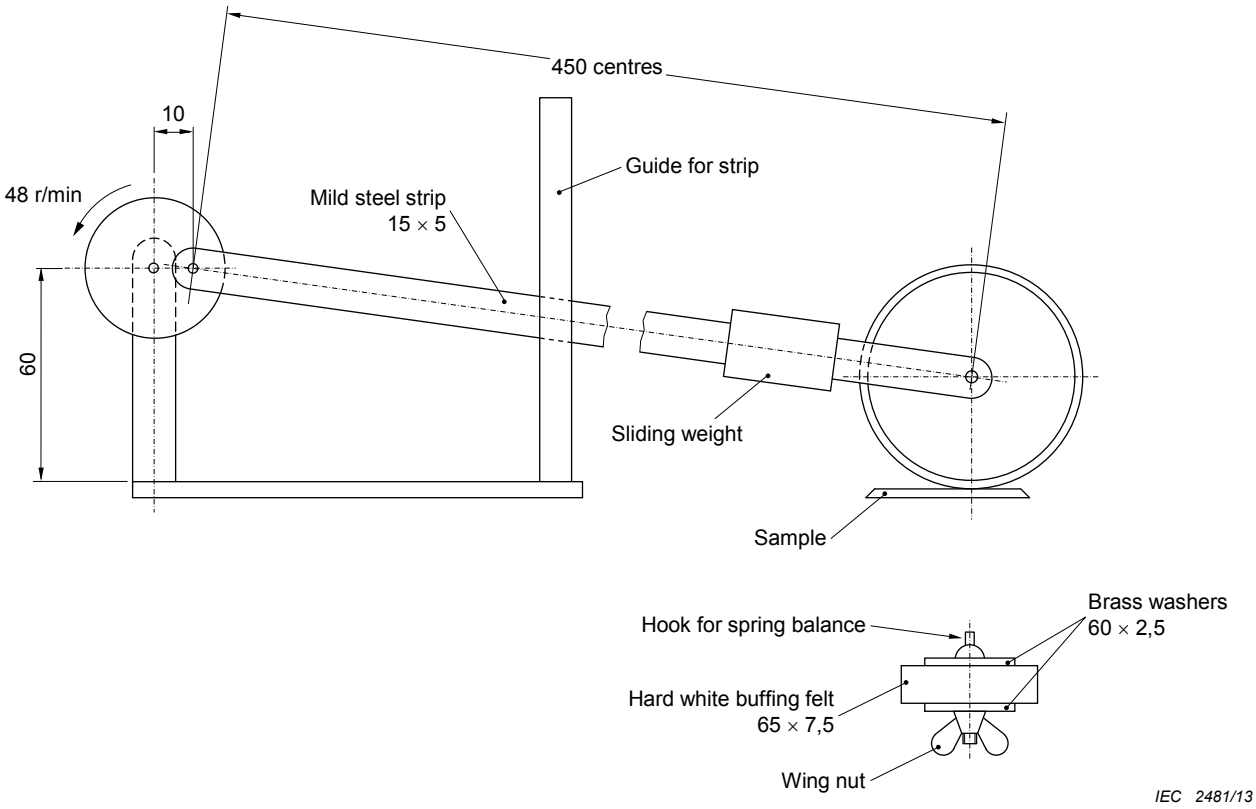


Figure 8 – Apparatus for testing durability of markings on rating labels

Dimensions in millimetres

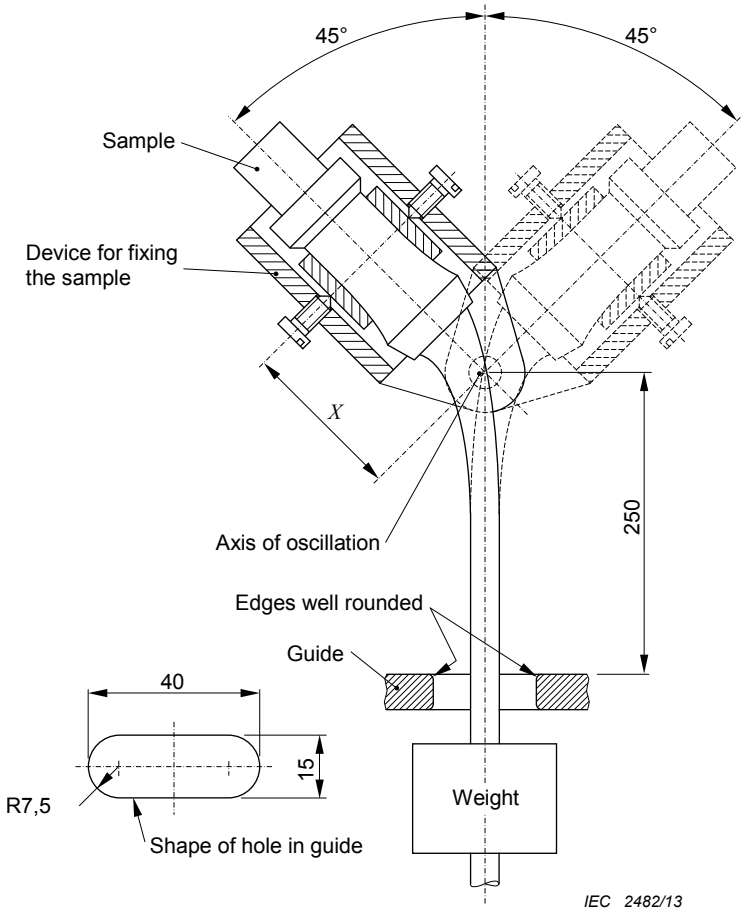
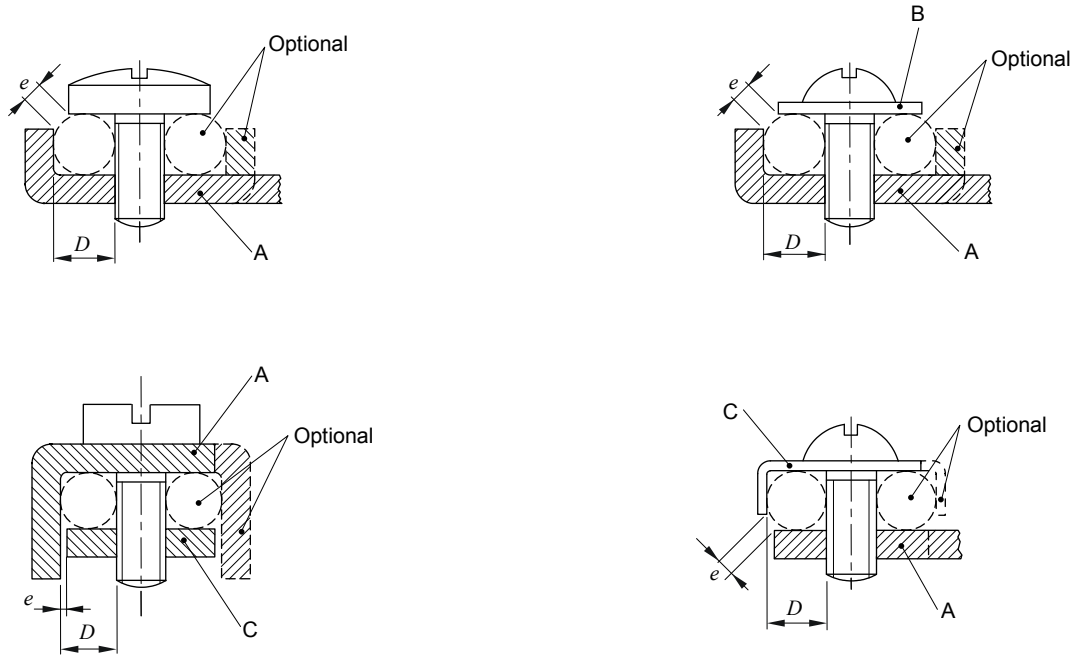


Figure 9 – Apparatus for flexing test

Screws not requiring washer, clamping plate or anti-spread device

Screws requiring washer, clamping plate or anti-spread device



Screw terminals

Stud terminals

IEC 2483/13

A fixed part

B washer or clamping plate

C anti-spread device

D conductor space

E stud

Figure 10 – Screw terminals and stud terminals (*1 of 2*)

Dimensions in millimetres

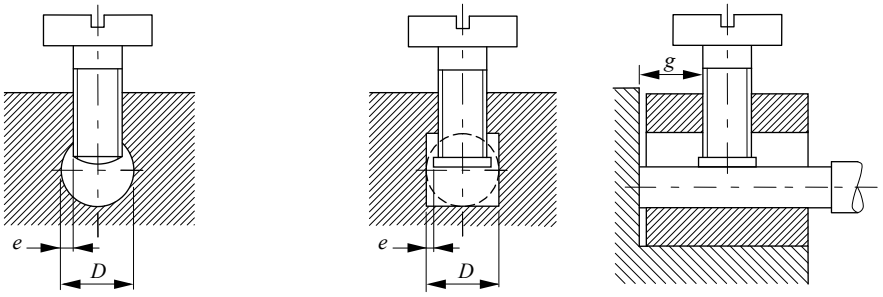
Current carried by terminal [a]		Minimum diameter conductor space	Maximum gap between conductor restraining parts	Minimum torque Nm			
				Slotted screws		Other screws	
For flexible conductor	For fixed conductor			One screw	Two screws	One screw	Two screws
A	A	*D*	*e*	*g*	*g*		
0-6	0-6	1,4	1,0	0,4	–	0,4	–
6-10	0-6	1,7	1,0	0,5	–	0,5	–
10-16	6-10	2,0	1,5	0,8	–	0,8	–
16-25	10-16	2,7	1,5	1,2	0,5	1,2	0,5
25-32	16-25	3,6	1,5	2,0	1,2	2,0	1,2
–	25-32	4,3	2,0	2,0	1,2	2,0	1,2
32-40	32-40	5,5	2,0	2,0	1,2	2,0	1,2
40-63	40-63	7,0	2,0	2,0	2,0	3,0	2,0

The part which retains the conductor in position may be of insulating material, provided that the pressure necessary to clamp the conductor is not transmitted through the insulating material.

The sketches are not intended to govern design except as regards the dimensions shown.

[a] Requirements for applications greater than 63 A are under consideration.

Figure 10 – Screw terminals and stud terminals (*2 of 2*)



Terminal without pressure plate

Terminal with pressure plate

IEC 2484/13

Dimensions in millimetres

Current carried by terminal [a]		**Minimum diameter con-ductor space**	**Maximum gap between conductor restraining parts**	**Minimum distance between clamping screw and end of conductor when fully inserted**		**Minimum torque** Nm					
For flexible con-ductor A	**For fixed con-ductor** A					**Screws without heads**		**Slotted screws**		**Other screws**	
		D	*e*	**One screw** *g*	**Two screws** *g*	**One screw**	**Two screws**	**One screw**	**Two screws**	**One screw**	**Two screws**
0-10	0-6	2,5	0,5	1,5	1,5	0,2	0,2	0,4	0,4	0,4	0,4
10-16	6-10	3,0	0,5	1,5	1,5	0,25	0,2	0,5	0,4	0,5	0,4
16-25	10-16	3,6	0,5	1,8	1,5	0,4	0,2	0,8	0,4	0,8	0,4
25-32	16-25	4,0	0,6	1,8	1,5	0,4	0,25	0,8	0,5	0,8	0,5
-	25-32	4,5	1,0	2,0	1,5	0,7	0,25	1,2	0,5	1,2	0,5
32-40	32-40	5,5	1,3	2,5	2,0	0,8	0,7	2,0	1,2	2,0	1,2
40-63	40-63	7,0	1,5	3,0	2,0	1,2	0,7	2,5	1,2	3,0	1,2

The part of the terminal containing the threaded hole and the part of the terminal against which the conductor is clamped by the screw may be two separate parts; as in the case of terminals provided with a stirrup.

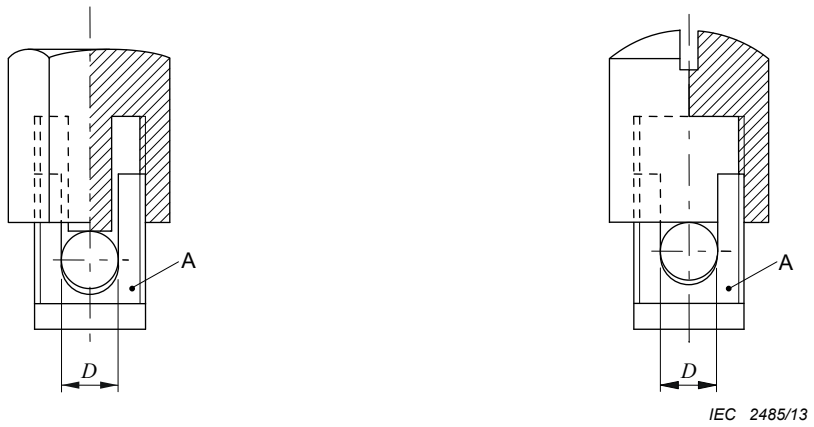
The shape of the conductor space may differ from those shown in the figures, provided a circle with a diameter equal to the minimum value specified for *D* can be inscribed.

The minimum distance between the clamping screw and the end of the conductor when fully inserted applies only to the terminals in which the conductor cannot pass right through.

The sketches are not intended to govern design except as regards the dimensions shown.

[a] Requirements for applications greater than 63 A are under consideration.

Figure 11 – Pillar terminals



A fixed part

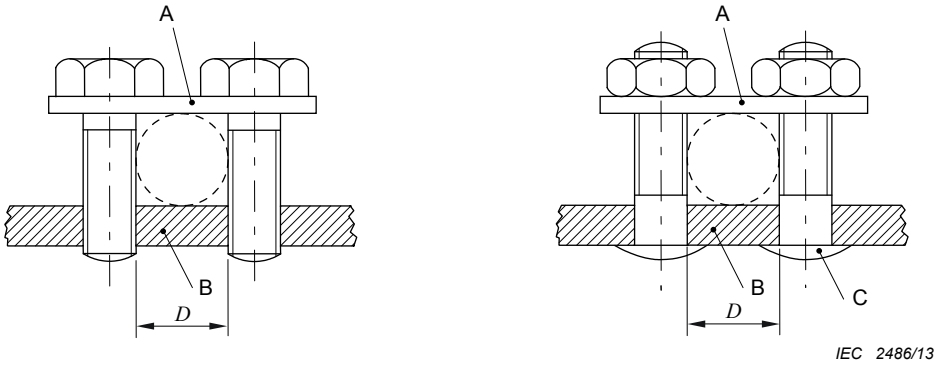
D conductor space

The bottom of the conductor space must be slightly rounded, in order to obtain a reliable connection.

Terminal size	**Minimum diameter of conductor space** [a] mm	**Minimum distance between fixed part and end of conductor when fully inserted** mm
0	1,4	1,5
1	1,7	1,5
2	2,0	1,5
3	2,7	1,8
4	3,6	1,8
5	4,3	2,0
6	5,0	2,5
7	7,0	3,0
8	8,5	4,0

[a] The value of the torque to be applied is that specified in Table 20.

Figure 12 – Mantle terminals



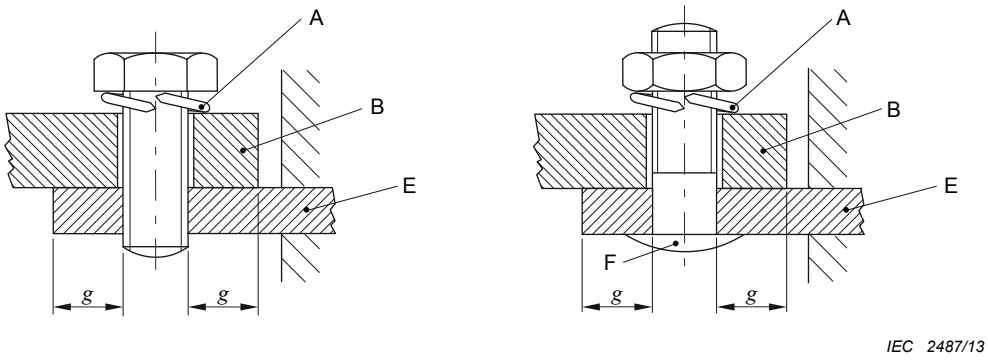
A saddle

B fixed part

C stud

D conductor space

a) Saddle terminals



A locking means

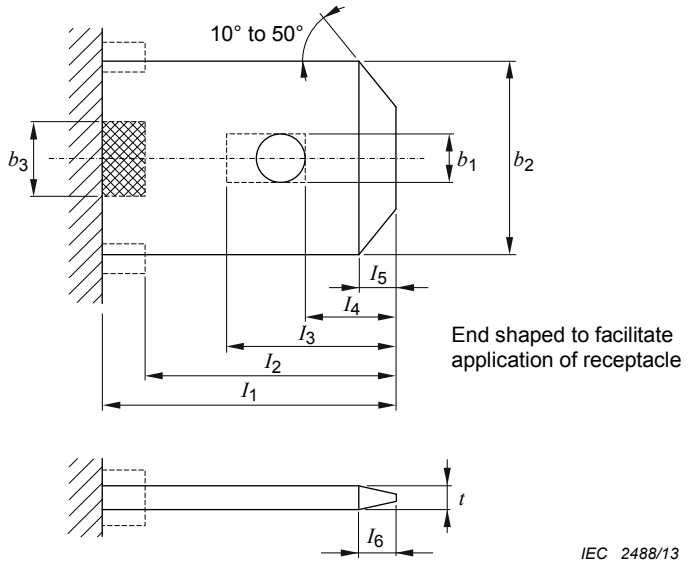
B cable lug or bar

E fixed part

F stud

b) Lug terminals

Figure 13 – Saddle and lug terminals



Dimensions in millimetres

Dimension for Figures 14 and 15 [a]	Connector size			
	2,8	**4,8**	**6,3**	**9,5**
l_1 (min.) [b]	7,7	6,9	8,6	14,0
l_2 (min). [b]	7,0	6,2	7,9	12,0
l_3 (max.) [c]	3,0	5,2	6,7	8,2
l_4	1,0 ± 0,2	2,5 ± 0,25	3,2 ± 0,3	4,2 ± 0,3
l_5 (max.)	0,7	1,2	1,3	1,7
l_6 (max.)	0,7	1,2	1,3	1,7
b_1 (hole) [a]	$1{,}2\ ^{+0,1}_{0}$	$1{,}4\ ^{+0,2}_{0}$	$1{,}6\ ^{+2,0}_{0}$ [d]	$2{,}1\ ^{+2,0}_{0}$ [d]
b_1 (slot) [a]	$1{,}2\ ^{+0,1}_{0}$	$1{,}4\ ^{+0,2}_{0}$	$1{,}6\ ^{+0,1}_{0}$	$2{,}1\ ^{+2,0}_{0}$
b_2	2,8 ± 0,1	4,75 ± 0,2	$6{,}3\ ^{+0,15}_{-0,1}$	$9{,}5\ ^{+0,15}_{-0,1}$
b_3 (min.) [e]	2,0	2,0	2,5	2,5
t [f]	0,5 ± 0,025	0,8 ± 0,03	0,8 ± 0,03	1,2 ± 0,03
p (max.) [g]	0,8	1,2	1,2	1,7
k	–	$0{,}7\ ^{0}_{-0,1}$	$1{,}0\ ^{0}_{-0,1}$	$1{,}5\ ^{0}_{-0,1}$
x	–	1,0 ± 0,2	1,0 ± 0,2	1,4 ± 0,2

NOTE The sketches are not intended to govern design except as regards the dimensions shown.

[a] Ⓒ Tabs may have an optional detent for latching. Round dimple detents, rectangular dimple detents and hole detents shall be located in the area bounded by dimensions b_1, l_3 and l_4 along the centre line of the tab. Ⓒ

Tabs may be manufactured from more than one layer of materials, provided that the resulting **tab** complies with this standard.

Details for **tabs** having corrugations or depressions are under consideration.

[b] In order to provide sufficient **clearance** for **receptacles** intended to be provided with a sleeve, it may be necessary to increase this dimension by 0,5 mm to ensure that the means of location operates correctly.

[c] The length of the slot (l_3-l_4) must be at least equal to its width (b_1).

[d] These tolerances are chosen so as to allow the **tabs** to be used as a part of a terminal with screw clamping.

[e] Over the double-hatched area, the thickness shall not exceed the upper limit of the material thickness specified.

[f] With the exception of the dimple or hole and the area indicated by dimension "b", the thickness "t" shall be maintained over the whole connecting area. Compliance shall be determined by measurement over any section (3,2 ± 0,2) mm^2, in a circular area. In addition, the overall flatness shall have a tolerance of 0,03 mm.

[g] This dimension applies only to the raised side of the **tab**; on the reverse side, the flatness tolerance extends across the full width of the **tab**.

Figure 14 – Tabs

For dimensions, see Figure 14

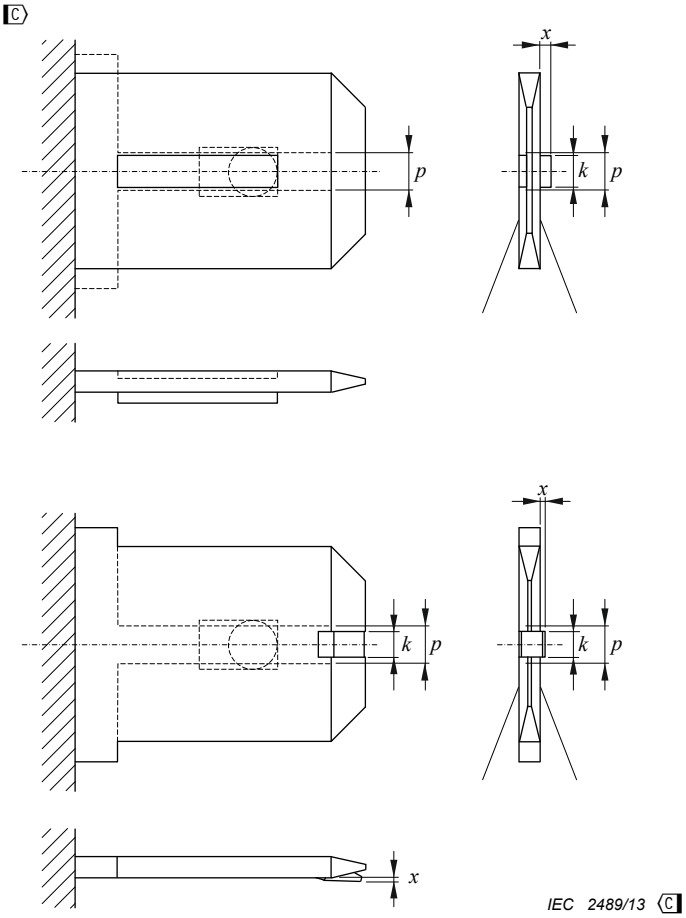
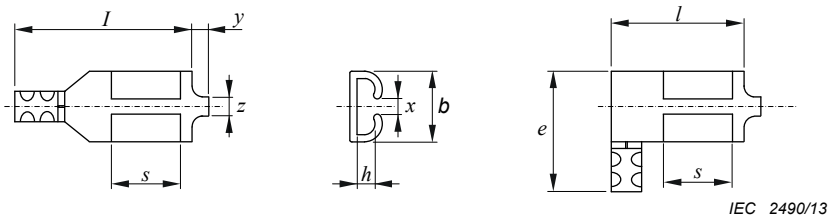


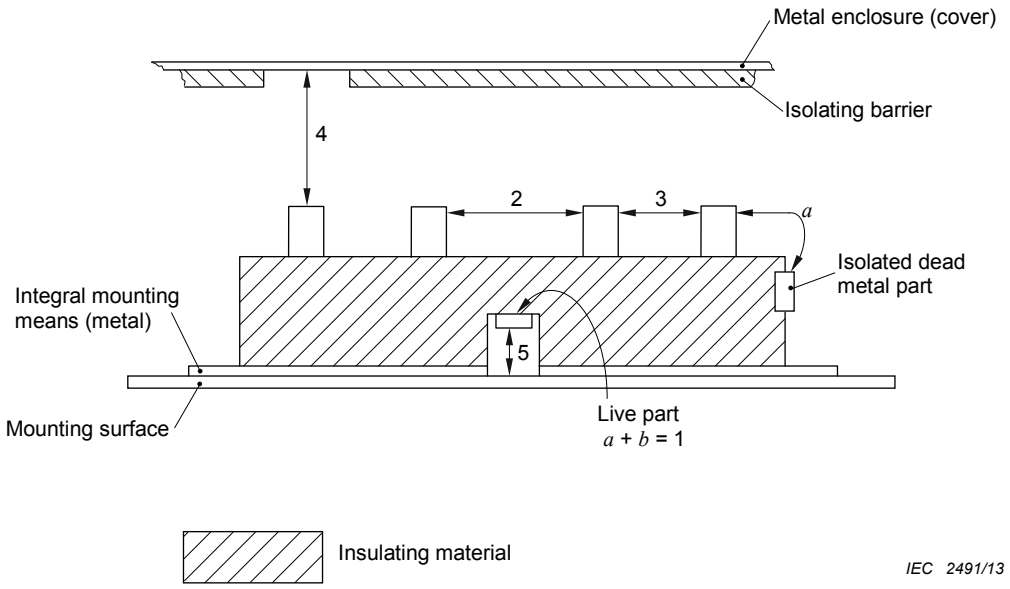
Figure 15 – Tabs for non-reversible connectors



Dimensions in millimetres

Dimension	Connector size			
	2,8	**4,8**	**6,3**	**9,5**
b (max.)	4	6	8	12,5
e (max.)	12	12	15	20
h (max.)[a]	1	2	2,5	3,2
l (max.)	18	18	22	27
s (min.)	4,5	5	6	10
x (min.)[b]	-	0,9	1,2	1,7
y (max.)	0,5	0,5	0,5	1,0
z (max.)	1,5	1,5	2,0	2,0
The dimensions shown apply to the crimped condition. Dimensions for **receptacles** provided with a sleeve and for **receptacles** with a pre-insulated barrel are under consideration. The sketches are not intended to govern design except as regards the dimensions shown.				
[a] Maximum offset dimension from the centre line of the **tab** blade. [b] Applies only to **receptacles** for non-reversible connectors.				

Figure 16 – Receptacles



1 = between **live parts** and other metal parts (including physically exposed electrical isolated metal parts)

2 = between **live parts** required to be insulated from each other (**functional insulation**), except between contacts.

3 = between **live parts** separated by the action of the **control** (**same polarity**)
a **full disconnection**
b these distances do not apply between terminals intended for connection to **fixed wiring**

4 = between **live parts** and metal enclosure of enclosed **controls** (these distances do not apply to the housing, frame or integral mounting means of a **control** intended for installation within an enclosure of the equipment controlled).

5 = between **live parts** in recesses of **independently mounted controls** and the surface to which the **control** is mounted. This distance may be reduced with the addition of an appropriate seal or barrier.

Figure 17 – Measurement of creepage distance and clearance

Annex A
(normative)

Indelibility of markings

A.1 Markings on **controls** shall be adequately indelible for safety and are therefore classified according to the requirements for indelibility:

A.1.1 Markings which are not mandatory within the requirements of this standard.

A.1.2 Markings which are mandatory within the requirements of this standard but which are not accessible to the final **user** when the **control** is mounted or installed in the equipment.

These markings have to be sufficiently resistant to removal to withstand the manual handling in the **control manufacturer's** factory after final inspection, being packed and transported to the **equipment manufacturer's** factory, and handled during installation. Additionally, the marking shall remain legible in the presence of any vapour or other contaminant likely to be present.

A.1.3 Markings which are mandatory within the requirements of this standard and which are accessible to the final **user** of the equipment after the **control** is mounted or installed as for **normal use**.

These markings, in addition to being resistant to the handling, etc., described in A.1.2, have also to withstand the rubbing and handling expected during the use of the equipment. Markings on knobs, etc., shall survive the continual handling and rubbing as a result of manual **actuation**. Other markings should be resistant to cleaning, polishing and the like.

A.1.4 *Compliance with the requirements for indelibility of markings classified according to A.1.2 and A.1.3 is checked by the tests of Clause A.2 or A.3 using the apparatus shown in Figure 8.*

The principal part consists of a disc of hard white buffing felt, 65 mm in diameter and 7,5 mm thick. This is locked against rotation and is arranged to move across the surface to be tested with a stroke of 20 mm and to exert a measurable force on this surface. The standard test shall be 12 strokes (i.e., rotations of the eccentric) and shall take approximately 15 s.

During the tests, the appropriate part of the buffing disc is covered with one layer of white absorbent lint with the nap surface external.

A1 *The solvents used are:*

- *neutral liquid detergent blended from alkyl benzene sulphonate and non-ionic detergents or 2 % of a solvent in deionized (distilled) water where the solvent consists of:*
  - *70 % (with volume) Natriumdodecylbenzylsulfonat, (Isomere), formula: C18H29NaO3S, CAS-No. 25155-30-0, and*
  - *30 % (with volume) Glycerin (other names: Glycerol, 1,2,3-Propantriol, Propantriol,E 422), formula: C3H8O3, CAS-No. 56-81-5;*
- *n-hexane (aliphatic solvent hexane with a content of aromatics of maximum 0,1 volume %, initial boiling point of approximately 69 °C and specific gravity of approximately 0,66 g/cm^3, CAS-No. 110-54-3), and*
- *deionized (distilled) water.* A1

A.2 *Compliance with the requirements for indelibility of markings classified according to A.1.2 is checked by the following tests:*

A.2.1 *The markings under consideration shall withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period, the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

A.2.2 *The sample shall then be allowed to dry completely in an ambient room temperature of (25 ± 5) °C.*

A.2.3 *The sample shall then be rubbed in the apparatus of Figure 8, using dry lint and a weight of 250 g measured as indicated.*

A.2.4 *The sample shall then be rubbed using water-soaked lint and a weight of 250 g.*

A.2.5 *If the shape or position of marking is such that it cannot be bleached or rubbed with this apparatus (for example, by recessing the marked surface) then the tests of A.2.3 and A.2.4 are not applied.*

A.2.6 *At the conclusion of these tests, the marking shall still be legible.*

A.3 *Compliance with the requirements for indelibility of markings classified according to A.1.3 is checked by the following tests:*

A.3.1 *The marking under consideration shall be rubbed in the apparatus of Figure 8 using a dry lint and a weight of 750 g.*

A.3.2 *The marking shall then be rubbed in the apparatus using a water-soaked lint and a weight of 750 g.*

A.3.3 *The marking under consideration shall then withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period, the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

A.3.4 *After being allowed to dry it shall be rubbed in the apparatus using a detergent soaked lint and a weight of 750 g.*

A.3.5 *After surplus detergent has been shaken off it shall be rubbed in the apparatus, using a petroleum spirit soaked lint and a weight of 750 g.*

A.3.6 *For the tests of A.3.1 to A.3.5 the thickness of the buffing disc may be progressively reduced from 7,5 mm in order that the marking may be reached and rubbed. However, the minimum thickness of the buffing disc shall be not less than 2,5 mm. If the thickness of the buffing disc is reduced the weight of 750 g shall be reduced in linear proportion.*

A.3.7 *At the conclusion of these tests, the marking shall still be legible.*

Annex B
(normative)

Measurement of creepage distances and clearances in air

*When determining and measuring **creepage distances** and **clearances**, the following assumptions are made, where D is equal to the **clearance** in air prescribed for the distance under consideration (see Figures B.1 to B.11 for examples of methods of measurement of **creepage distance** and **clearances**):*

- *a groove may have parallel, converging or diverging side walls;*
- *if a groove has diverging side walls, it is regarded as an air gap if its minimum width exceeds $D/12$, its depth exceeds D/2 and its width at the bottom of the groove is at least equal to $D/3$ (see Figure B.8) but in no case smaller than the minimum value X as permitted in the tabulation below;*
- *any corner having an angle less than 80 ° is assumed to be bridged by an insulating link having a width equal to $D/3$ or 1 mm, whichever is less, which is placed in the most unfavourable position (see Figure B.3);*
- *if the distance across the top of a groove is a least equal to $D/3$, or 1 mm, whichever is less, the **creepage distance** path follows the contour of the groove unless otherwise specified immediately above (see Figure B.2);*
- *for **creepage distances** and **clearances** in air between parts moving relatively one to another, these parts are considered to be in their most unfavourable position to each other;*
- ***creepage distances** determined according to these rules are not less than the corresponding (measured) **clearances** in air;*
- *any air gap having a width less than $D/3$ or 1 mm, whichever is less, is ignored in calculating the total **clearance** in air;*
- *for inserted or set-up barriers, the **creepage distances** are measured through the joint unless the parts are so cemented or heat-sealed together that ingress of humidity or dirt into the joint is not liable to occur.*

In the examples shown in Figures B.1 to B.10, the following identification is used:

▪▪▪▪▪▪▪▪▪▪▪ is a **creepage distance**;

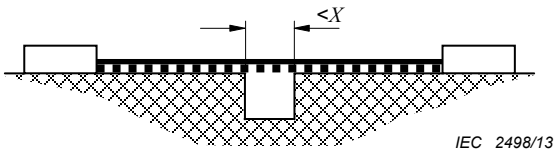
▬▬▬▬▬▬▬▬ is a **clearance** in air.

See Table B.1 for the value of X.

Table B.1 – Value of X

Pollution degree	***Width X of grooves: minimum values*** *mm*
1	*0,25*
2	*1,0*
3	*1,5*
4	*2,5*

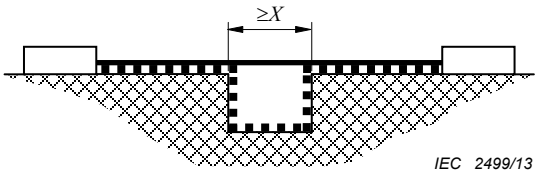
*If the associated **clearance** is less than 3 mm, the minimum groove width may be reduced to one-third of this **clearance**.*



The path under consideration includes a groove of any depth, having a width less than X.

Rule: The **clearance** path is the "line of sight" path.

Figure B.1 – Narrow groove

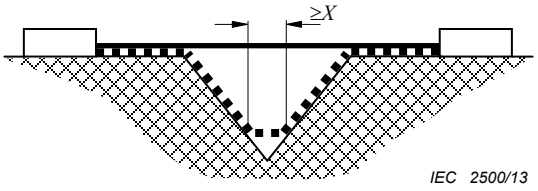


The path under consideration includes a groove of any depth, having a width equal to or more than X.

Rule: The **clearance** path is the "line of sight" path.

The **creepage distance** path follows the contour of the groove.

Figure B.2 – Wide groove



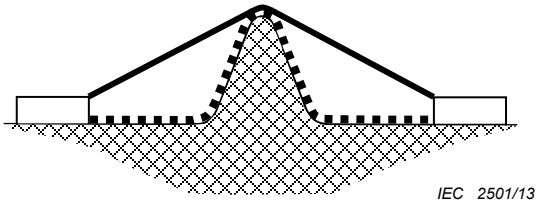
The path under consideration includes a V-shaped groove having a width greater or equal to X.

Rule: The **clearance** path is the "line of sight" path.

The **creepage distance** path follows the contour of the groove except that it bridges the groove where its width is equal to X.

Figure B.3 – V-shaped groove

Clearance **Creepage distance**

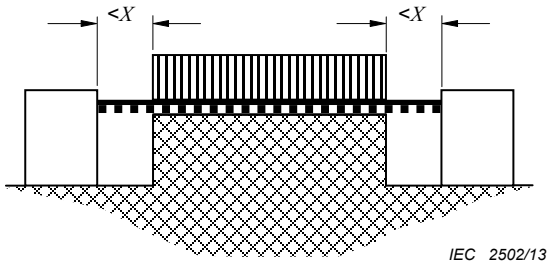


The path under consideration includes a rib.

Rule: The **clearance** path is the shortest air path over the top of the rib.

The **creepage distance** path follows the contour of the rib.

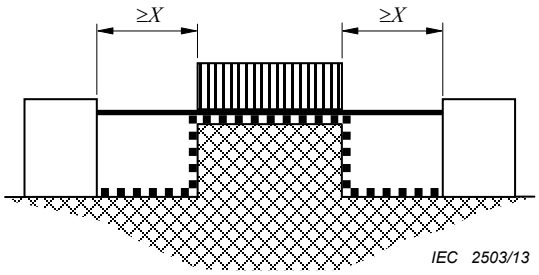
Figure B.4 – Rib



The path under consideration includes an uncemented joint and grooves having a width less than X on either side.

Rule: The **creepage distance** path and the **clearance** path is the "line of sight" path as shown.

Figure B.5 – Uncemented joint with narrow groove



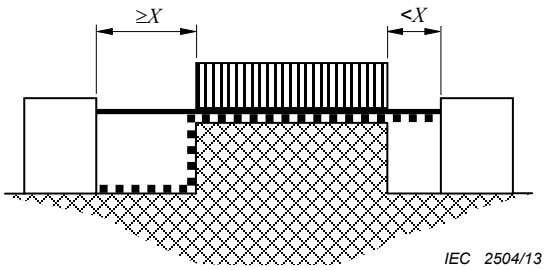
The path under consideration includes an uncemented joint and grooves having a width equal to or more than X.

Rule: The **clearance** path is the "line of sight" path as shown.

The **creepage distance** path follows the contour of the grooves.

Figure B.6 – Uncemented joint with wide groove

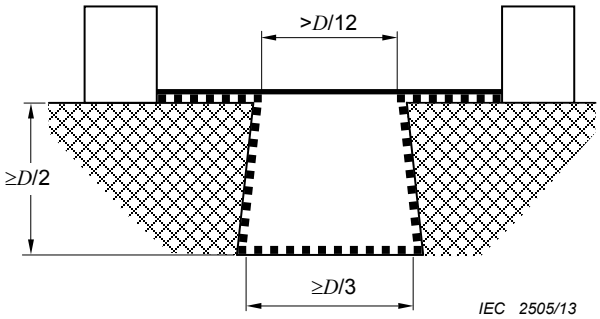
Clearance **Creepage distance**



The path under consideration includes an uncemented joint, a groove on one side having a width less than X, and a groove on the other having a width equal to or more than X.

Rule: The **clearance** path and the **creepage distance** path are as shown.

Figure B.7 – Uncemented joint with narrow and wide grooves



The path under consideration includes a groove having diverging side walls, a depth equal to or greater than $D/2$ and a width exceeding $D/12$ at the narrowest part and equal to or greater than $D/3$ at the bottom.

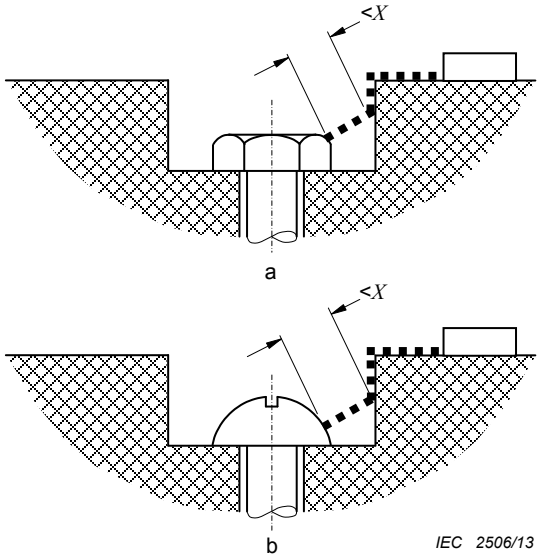
Rule: The **clearance** path is equal to the "line of sight" path.

The **creepage distance** path follows the contour of the groove.

The rule for Figure B.3 applies as well to the internal corners if they are less than 80°.

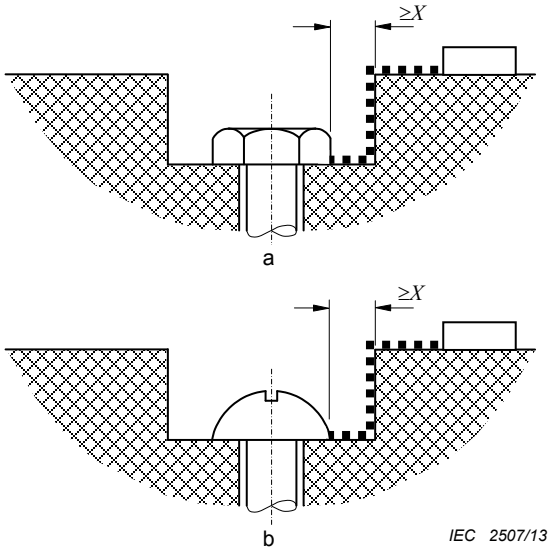
Figure B.8 – Diverging side walls

Clearance **Creepage distance**



Gap between head of screw and wall of recess too narrow to be taken into account for the creepage distance path.

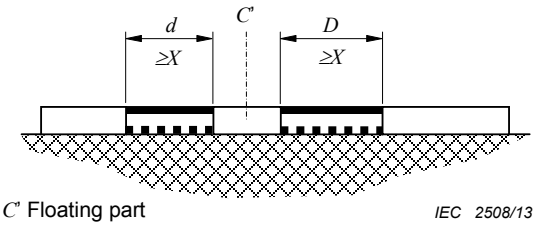
Figure B.9 – Narrow recess



Gap between head of screw and wall of recess wide enough to be taken into account for the creepage distance path.

Figure B.10 – Wide recess

Clearance **Creepage distance**



Clearance is the distance $d + D$

Creepage distance is also $d + D$

Clearance **Creepage distance**

Figure B.11 – Conductive floating part

Annex C
(normative)

Cotton used for mercury switch test
(not applicable in the countries members of CENELEC)

〖C〉 Void 〈C〗

Annex D
(informative)

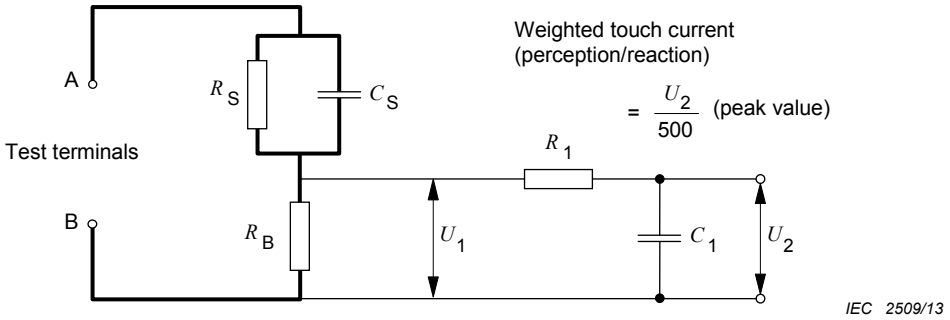
Heat, fire and tracking

〈C〉 Void 〈C〉

Annex E
(normative)

Circuit for measuring leakage current

A suitable circuit for measuring **leakage current** in accordance with H.8.1.10 is shown in Figure E.1.



R_S	1 500 Ω	R_1	10 000 Ω
R_B	500 Ω	C_1	0,022 μF
C_S	0,22 μF		

NOTE This figure is taken from IEC 60990:1999, Figure 4.

Figure E.1 – Circuit for measuring leakage currents

Annex F
(informative)

Fire hazard testing

Information for **controls** to be integrated or incorporated into appliances according to the IEC 60335 series is given by a reference to IEC 60335-1.

Annex G
(normative)

Heat and fire resistance tests

G.1 Void

G.2 Glow-wire test

The glow-wire test is carried out in accordance with IEC 60695-2-10 and IEC 60695-2-11.

*The glow-wire test shall be carried out on the complete **control**. If this is not possible: on parts removed from the **control**. If this is not possible: on test plaques of similar thickness but not thicker than the part.*

G.3 Void

G.4 Proof tracking test

The proof tracking test is made in accordance with IEC 60112.

For the purpose of this standard, the following applies:

- *In Clause 5 of IEC 60112:2003, Test specimen, Note 3 also applies to the proof tracking tests of Clause 10 of IEC 60112:2003.*
- *In Clause 7 of IEC 60112:2003, Test apparatus, Note 1 in 7.1 does not apply. The test solution A described in 7.3 of IEC 60112:2003, Amendment 1:2009 is used.*
- *In 7.3 of IEC 60112:2003, Amendment 1:2009, Test solutions, Solution A shall be used generally.*
- *In 8.2 of IEC 60112:2003, "Preparation", the voltage referred to in the last sentence is set in 21.2.7 of this standard. The proof tracking test of Clause 10 of IEC 60112:2003 is carried out, five times.*

G.5 Ball pressure test

The ball pressure test is carried out in accordance with IEC 60695-10-2 (see Figure 6 for test apparatus).

G.5.1 Ball pressure test 1

For the purpose of this standard, the temperature in the heating oven is the highest of:

- *20 °C ± 2 K in excess of the maximum temperature measured during the tests of Clause 14,*
- *75 °C ± 2 °C,*
- *as declared.*

NOTE 1 For **controls** intended for incorporation into appliances within the scope of IEC 60335-1 the temperature might differ as per 30.1 of that standard.

The support and the ball shall be at the prescribed test temperature before the test is started.

NOTE 2 The test is not made on parts of ceramic material and glass.

G.5.2 Ball pressure test 2

The ball pressure test is carried out as described in G.5.1 except that the temperature in the heating oven shall be $T_b \pm 2$ °C where T_b is equal to the higher of:

– *100 °C when T_{max} is 30 °C and up to, but excluding, 55 °C;*

– *125 °C when T_{max} is 55 °C and up to, but excluding, 85 °C;*

– *$T_{max} + 40$ °C if T_{max} is 85 °C or above;*

– *20 K in excess of the maximum temperature recorded during the heating test of Clause 14;*

– *the temperature achieved during the test of H.27.1.1.3, if this is higher than the temperature given in the preceding four dashed paragraphs.*

NOTE For **controls** intended for incorporation into appliances within the scope of IEC 60335-1, the temperature might differ as per 30.1 of that standard.

Annex H
(normative)

Requirements for electronic controls

Annex H supplements or modifies the corresponding clauses of this standard.

H.2 Terms and definitions

H.2.4 Definitions relating to disconnection and interruption

H.2.4.2 *Addition:*

NOTE An **electronic device** does not provide this disconnection.

H.2.4.3 *Addition*:

NOTE An **electronic device** does not provide this disconnection.

H.2.4.4 *Addition:*

NOTE An **electronic device** does not provide this disconnection.

Add the following definition:

H.2.4.6
electronic disconnection
non-cycling interruption by an **electronic device** of a circuit for functional disconnection and which provides a disconnection other than by means of an air gap by satisfying certain electrical requirements in at least one pole

Note 1 to entry: **Electronic disconnection** ensures that, for all non-**sensing controls**, the function controlled by the disconnection is secure and that, for all **sensing controls**, the function controlled is secure between the limits of the **activating quantity** declared in Table 1, requirement 36.

The disconnection may be obtained by an **automatic action** or a **manual action**.

Some **controls** may incorporate circuit disconnections of more than one form.

Electronic disconnection may not be suitable for some applications. See Clause H.28.

H.2.5 Definitions of type of control according to construction

Add the following definitions:

H.2.5.7
electronic control
control which incorporates at least one **electronic device**

H.2.5.8
electronic device
device which produces a dynamic imbalance of electrons

Note 1 to entry: The essential function and construction are based on semi-conductor device, vacuum tube or gas discharge tube technology.

H.2.5.9
electronic assembly
group of components, at least one of which is an **electronic device**, but in which individual parts may be replaced without damage to the assembly

Note 1 to entry: An example of this is a group of components mounted on a printed circuit board.

H.2.5.10
integrated circuit
electronic device contained within the bulk of a semi-conductor material and interconnected at or near the surface of that material

Note 1 to entry: The semi-conductor material is normally enclosed within some form of encapsulation.

H.2.5.11
hybrid circuit
circuit produced on ceramic substrate by means of thick film, thin film or surface-mounted devices (SMD) technology, without accessible electrical connections except for I/O points, and with all internal connections constructed as part of a lead frame or other integral construction

H.2.7 Definitions relating to protection against electric shock

Add the following definition:

H.2.7.14
protective impedance
impedance connected between **live parts** and accessible conductive parts, of such value that the current, in **normal use** and under likely **fault** conditions in the equipment, is limited to a safe value

Add the following definitions:

H.2.16 Definitions relating to the structure of controls using software

H.2.16.1
dual channel
structure which contains two mutually **independent** functional means to execute specified **operations**

Note 1 to entry: Special provision may be made for control of **common mode fault/errors**. It is not required that the two channels each be algorithmic or logical in nature.

H.2.16.2
dual channel (diverse) with comparison
dual channel structure containing two different and mutually **independent** functional means, each capable of providing a declared response, in which comparison of output signals is performed for **fault**/error recognition

H.2.16.3
dual channel (homogeneous) with comparison
dual channel structure containing two identical and mutually **independent** functional means, each capable of providing a declared response, in which comparison of internal signals or output signals is performed for **fault**/error recognition

H.2.16.4
single channel
structure in which a single functional means is used to execute specified **operations**

H.2.16.5
single channel with functional test
single channel structure in which test data is introduced to the functional unit prior to its **operation**

H.2.16.6
single channel with periodic self-test
single channel structure in which components of the **control** are periodically tested during **operation**

H.2.16.7
single channel with periodic self-test and monitoring
single channel structure with periodic self-test in which **independent** means, each capable of providing a declared response, monitor such aspects as safety-related timing, sequences and software operations

H.2.17 Definitions relating to error avoidance in controls using software

H.2.17.1
dynamic analysis
method of analysis in which inputs to a **control** are simulated and logic signals at the circuit nodes are examined for correct value and timing

H.2.17.2
failure rate calculation
calculation of the theoretical number of **failures** of a given kind per unit

Note 1 to entry: For example, **failures** per hour or **failures** per cycle of **operation**.

H.2.17.3
hardware analysis
evaluation process in which the circuitry and components of a **control** are examined for correct function within their specified tolerances and ratings

H.2.17.4
hardware simulation
method of analysis in which circuit function and component tolerances are examined by use of a computer model

H.2.17.5
inspection
evaluation process in which the hardware or the software specification, design or code is examined in detail by a person or group other than the designer or programmer in order to identify possible errors

Note 1 to entry: In contrast to the **walk-through**, the designer or programmer is passive during this evaluation.

H.2.17.6
operational test
evaluation process in which a **control** is operated under the extremes of its intended operating conditions (for example, cycle rate, temperature, voltage) to detect errors in design or construction

H.2.17.7 Static analysis

H.2.17.7.1
static analysis – hardware
evaluation process in which a hardware model is systematically assessed

Note 1 to entry: The evaluation may typically be computer-aided and may include examination of parts lists and circuit layouts, an interface analysis and functional checks.

H.2.17.7.2
static analysis – software
evaluation process in which a software programme is systematically assessed without necessarily executing the programme

Note 1 to entry: The evaluation may typically be computer-aided and usually includes analysis of such features as programme logic, data paths, interfaces and variables.

H.2.17.8
systematic test
method of analysis in which a **system** or a software programme is assessed for correct execution by the introduction of selected test data

Note 1 to entry: For example see **black box test** and **white box test**.

H.2.17.8.1
black box test
systematic test in which test data derived from the functional specification is introduced to a functional unit to assess its correct **operation**

H.2.17.8.2
white box test
systematic test in which test data based on the software specification is introduced to a programme to assess the correct **operation** of subparts of the programme

Note 1 to entry: For example, data may be selected to execute as many instructions as possible, as many branches as possible, as many subroutines as possible, etc.

H.2.17.9
walk-through
evaluation process in which a designer or programmer leads members of an evaluation team through the hardware design, software design and/or software code the designer or programmer has developed in order to identify possible errors

Note 1 to entry: In contrast to the **inspection**, the designer or programmer is active during this review.

H.2.17.10
software fault/error detection time
the period of time between the occurrence of a fault/error and the **initiation** by the software of a declared **control** response

H.2.18 Definitions relating to fault/error control techniques for controls using software

H.2.18.1 Bus redundancy

H.2.18.1.1
full bus redundancy
fault/error **control** technique in which full redundant data and/or address are provided by means of redundant bus structure

H.2.18.1.2
multi-bit bus parity
fault/error **control** technique in which the bus is extended by two or more bits and these additional bits are used for error detection

H.2.18.1.3
single bit bus parity
fault/error **control** technique in which the bus is extended by one bit and this additional bit is used for error detection

H.2.18.2
code safety
fault/error **control** techniques in which protection against coincidental and/or systematic errors in input and output information is provided by the use of **data redundancy** and/or **transfer redundancy** (see also H.2.18.2.1 and H.2.18.2.2)

H.2.18.2.1
data redundancy
form of **code safety** in which the storage of redundant data occurs

H.2.18.2.2
transfer redundancy
form of **code safety** in which data is transferred at least twice in succession and then compared

Note 1 to entry: This technique will recognize intermittent errors.

H.2.18.3
comparator
device used for **fault**/error **control** in **dual channel** structures

Note 1 to entry: The device compares data from the two channels and initiates a declared response if a difference is detected.

H.2.18.4
d.c. fault mode
stuck-at fault mode incorporating short circuits between signal lines

Note 1 to entry: Because of the number of possible shorts in the device under test, usually only shorts between related signal lines will be considered. A logical signal level is defined, which dominates in cases where the lines try to drive to the opposite level.

H.2.18.5
equivalence class test
systematic test intended to determine whether the instruction decoding and execution are performed correctly

Note 1 to entry: The test data is derived from the CPU instruction specification.

Note 2 to entry: Similar instructions are grouped and the input data set is subdivided into specific data intervals (equivalence classes). Each instruction within a group processes at least one set of test data, so that the entire group processes the entire test data set. The test data can be formed from the following:

– data from valid range;

– data from invalid range;

– data from the bounds;

– extreme values and their combinations.

The tests within a group are run with different addressing modes, so that the entire group executes all addressing modes.

H.2.18.6
error recognizing means
independent means provided for the purpose of recognizing errors internal to the **system**

Note 1 to entry: Examples are monitoring devices, **comparators**, and code generators.

H.2.18.7
Hamming distance
statistical measure, representing the capability of a code to detect and correct errors

Note 1 to entry: The **Hamming distance** of two code words is equal to the number of positions different in the two code words.

Note 2 to entry: See H. Holscher and J. Rader; "Microcomputers in safety techniques." Verlag TUV Bayern. TUV Rheinland. (ISBN 3-88585-315-9).

H.2.18.8
input comparison
fault/error **control** technique by which inputs that are designed to be within specified tolerances are compared

H.2.18.9
internal error detection
fault/error **control** technique in which special circuitry is incorporated to detect or correct errors

H.2.18.10 Programme sequence

H.2.18.10.1
frequency monitoring
fault/error **control** technique in which the clock frequency is compared with an **independent** fixed frequency

Note 1 to entry: An example is comparison with the line supply frequency.

H.2.18.10.2
logical monitoring of the programme sequence
fault/error **control** technique in which the logical execution of the programme sequence is monitored

Note 1 to entry: Examples are the use of counting routines or selected data in the programme itself or by **independent** monitoring devices.

H.2.18.10.3
time-slot and logical monitoring
this is a combination of H.2.18.10.2 and H.2.18.10.4

H.2.18.10.4
time-slot monitoring of the programme sequence
fault/error **control** technique in which timing devices with an **independent** time base are periodically triggered in order to monitor the programme function and sequence

Note 1 to entry: An example is a watchdog **timer**.

H.2.18.11
multiple parallel outputs
fault/error **control** technique in which **independent** outputs are provided for operational error detection or for **independent comparators**

H.2.18.12
output verification
fault/error **control** technique in which outputs are compared to **independent** inputs

Note 1 to entry: This technique may or may not relate an error to the output which is defective.

H.2.18.13
plausibility check
fault/error **control** technique in which programme execution, inputs or outputs are checked for inadmissible programme sequence, timing or data

Note 1 to entry: Examples are the introduction of an additional interrupt after completion of a certain number of cycles or checks for division by zero.

H.2.18.14
protocol test
fault/error **control** technique in which data is transferred to and from computer components to detect errors in the internal communications protocol

H.2.18.15
reciprocal comparison
fault/error **control** technique used in **dual channel** (homogeneous) structures in which a comparison is performed on data reciprocally exchanged between the two processing units

Note 1 to entry: Reciprocal refers to an exchange of similar data.

H.2.18.16
redundant data generation
availability of two or more **independent** means, such as code generators, to perform the same task

H.2.18.17
redundant monitoring
availability of two or more **independent** means such as watchdog devices and **comparators** to perform the same task

H.2.18.18
scheduled transmission
communication procedure in which information from a particular transmitter is allowed to be sent only at a predefined point in time and sequence, otherwise the receiver will treat it as a communication error

H.2.18.19
software diversity
fault/error **control** technique in which all or parts of the software are incorporated twice in the form of alternate software code

Note 1 to entry: For example, the alternate forms of software code may be produced by different programmers, different languages or different compiling schemes and may reside in different hardware channels or in different areas of memory within a **single channel**.

H.2.18.20
stuck-at fault mode
fault mode representing an open circuit or a non-varying signal level

Note 1 to entry: These are usually referred to as "stuck open", "stuck at 1" or "stuck at 0".

H.2.18.21
tested monitoring
the provision of **independent** means such as watchdog devices and **comparators** which are tested at start-up or periodically during **operation**

H.2.18.22
testing pattern
fault/error **control** technique used for periodic testing of input units, output units and interfaces of the **control**

Note 1 to entry: A test pattern is introduced to the unit and the results compared to expected values. Mutually **independent** means for introducing the test pattern and evaluating the results are used. The test pattern is constructed so as not to influence the correct **operation** of the **control**.

H.2.19 Definitions relating to memory tests for controls using software

H.2.19.1
Abraham test
specific form of a **variable memory** pattern test in which all stuck-at and coupling **faults** between memory cells are identified

Note 1 to entry: The number of **operations** required to perform the entire memory test is about 30 n, where n is the number of cells in the memory. The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments.

Note 2 to entry: See Abraham, J.A.; Thatte, S.M.; "Fault coverage of test programs for a microprocessor", Proceedings of the IEEE Test Conference 1979, pp 18-22.

H.2.19.2
GALPAT memory test
fault/error **control** technique in which a single cell in a field of uniformly written memory cells is inversely written, after which the remaining memory under test is inspected

Note 1 to entry: After each read **operation** to one of the remaining cells in the field, the inversely written cell is also inspected and read. This process is repeated for all memory cells under test. A second test is then performed as above on the same memory range without inverse writing to the test cell.

Note 2 to entry: The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments (see **transparent GALPAT test**).

H.2.19.2.1
transparent GALPAT test
GALPAT memory test in which first a signature word is formed representing the content of the memory range to be tested and this word is saved

Note 1 to entry: The cell to be tested is inversely written and the test is performed as above. However, the remaining cells are not inspected individually, but by formation of and comparison to a second signature word. A second test is then performed as above by inversely writing the previously inverted value to the test cell.

Note 2 to entry: This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

H.2.19.3 Checksum

H.2.19.3.1
modified checksum
fault/error **control** technique in which a single word representing the contents of all words in memory is generated and saved

Note 1 to entry: During self-test, a checksum is formed from the same algorithm and compared with the saved checksum.

Note 2 to entry: This technique recognizes all the odd errors and some of the even errors.

H.2.19.3.2
multiple checksum
fault/error **control** technique in which a separate words representing the contents of the memory areas to be tested are generated and saved

Note 1 to entry: During self-test, a checksum is formed from the same algorithm and compared with the saved checksum for that area.

Note 2 to entry: This technique recognizes all the odd errors and some of the even errors.

H.2.19.4 Cyclic redundancy check (CRC)

H.2.19.4.1
CRC – single word
fault/error **control** technique in which a single word is generated to represent the contents of memory

Note 1 to entry: During self-test, the same algorithm is used to generate another signature word which is compared with the saved word.

Note 2 to entry: This technique recognizes all one-bit, and a high percentage of multi-bit, errors.

H.2.19.4.2
CRC – double word
fault/error **control** technique in which at least two words are generated to represent the contents of memory

Note 1 to entry: During self-test, the same algorithm is used to generate the same number of signature words which are compared with the saved words.

Note 2 to entry: This technique can recognize one-bit and multi-bit errors with a greater accuracy than in **CRC – single word**.

H.2.19.5
redundant memory with comparison
structure in which the safety-related contents of memory are stored twice in different format in separate areas so that they can be compared for error control

H.2.19.6
static memory test
fault/error control technique which is intended to detect only static errors

H.2.19.6.1
checkerboard memory test
static memory test in which a checkerboard pattern of zeros and ones is written to the memory area under test and the cells are inspected in pairs

Note 1 to entry: The address of the first cell in each pair is variable and the address of the second cell is derived from a bit inversion of the first address. In the first **inspection**, the variable address is first incremented to the end of the address space of the memory and then decremented to its original value. The test is repeated with the checkerboard pattern inversed.

H.2.19.6.2
marching memory test
static memory test in which data is written to the memory area under test as in normal **operation**

Note 1 to entry: Every cell is then inspected in ascending order and a bit inversion performed on the contents. The **inspection** and bit inversion are then repeated in descending order. Then this process is repeated after first performing a bit inversion on all the memory cells under test.

H.2.19.7
walkpat memory test
fault/error control technique in which a standard data pattern is written to the memory area under test as in normal **operation**

Note 1 to entry: A bit inversion is performed on the first cell and the remaining memory area is inspected. Then the first cell is again inverted and the memory inspected. This process is repeated for all memory cells under test. A second test is conducted by performing a bit inversion of all cells in memory under test and proceeding as above.

Note 2 to entry: This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

H.2.19.8 Word protection

H.2.19.8.1
word protection with multi-bit redundancy
a **fault**/error control technique in which redundant bits are generated and saved for each word in the memory area under test

Note 1 to entry: As each word is read, a parity check is conducted.

Note 2 to entry: An example is a Hamming code which recognizes all one and two bit errors as well as some three bit and multi-bit errors.

H.2.19.8.2
word protection with single bit redundancy
a **fault**/error control technique in which a single bit is added to each word in the memory area under test and saved, creating either even parity or odd parity

Note 1 to entry: As each word is read, a parity check is conducted.

Note 2 to entry: This technique recognizes all odd bit errors.

H.2.20 Definitions of software terminology – General

H.2.20.1
common mode error
error(s) in a **dual channel** or other redundant structure such that each channel or structure is affected simultaneously and in the same manner

H.2.20.2
common cause error
errors of different items, resulting from a single event, where these errors are not consequences of each other

Note 1 to entry: **Common cause errors** should not be confused with **common mode errors**.

H.2.20.3
failure modes and effects analysis
FMEA
analytical technique in which the **failure** modes of each hardware component are identified and examined for their effects on the safety-related functions of the **control**

H.2.20.4
independent
not being adversely influenced by the control data flow and not being impaired by **failure** of other **control** functions, or by common mode effects

H.2.20.5
invariable memory
memory ranges in a processor system containing data which is not intended to vary during programme execution

Note 1 to entry: **Invariable memory** may include RAM construction where the data is not intended to vary during programme execution.

H.2.20.6
variable memory
memory ranges in a processor system containing data which is intended to vary during programme execution

H.2.21 Void

H.2.22 Definitions relating to classes of control functions

For the evaluation of protective measures for **fault** tolerance and avoidance of **hazards**, it is necessary to classify **control** functions with regard to their **fault** behaviour.

At the classification of **control** functions, their integration into the complete safety concept of the appliance shall be taken into account.

NOTE A **control** function consists of the entire loop beginning with the sensing means through the processing circuitry (hardware and software if used) and including the actuator drive.

For the purpose of evaluating the design of a **control** function, present requirements recognise three distinct classes:

H.2.22.1
class A control function
control functions which are not intended to be relied upon for the safety of the application

Note 1 to entry: Examples are: room **thermostats**, temperature **control**.

H.2.22.2
class B control function
control functions which are intended to prevent an unsafe state of the appliance

Note 1 to entry: **Failure** of the **control** function will not lead directly to a hazardous situation.

Note 2 to entry: Examples are: thermal limiter, pressure limiter.

H.2.22.3
class C control function
control functions which are intended to prevent special **hazards** such as explosion or whose **failure** could directly cause a **hazard** in the appliance

Note 1 to entry: Examples are: burner **control** systems, **thermal cut-outs** for closed water systems (without vent protection).

H.2.23 Definitions relating to functional safety

H.2.23.1
fault tolerating time
time between the occurrence of a **fault** and the shut-down of the controlled equipment, which is tolerated by the application without creating a hazardous situation

Note 1 to entry: Actions other than shut-down of the controlled equipment are possible if they can be shown to prevent hazardous situations.

H.2.23.2
fault reaction time
time between the occurrence of a **fault** and the point where the **control** has reached a **defined state**

H.2.23.3
defined state
state of a **control** with the following characterisation:

a) the **control** passively assumes a state in which the output terminals ensure a safe situation under all circumstances. When the cause of the transition to **defined state** is lifted, the application should start-up in accordance with the appropriate requirements; or

b) the **control** actively executes a protective action, within the time as specified in the relevant part 2, causing a shut-down, or preventing an unsafe condition; or

c) the **control** remains in **operation**, continuing to satisfy all safety related functional requirements

H.2.23.4
complex electronics
denote assemblies which use electronic components with the following characteristics:

a) the component provides more than one functional output;

b) it is impractical or impossible to represent the **failure** mode of such a component by stuck-at and cross-links at the pins or by other **failure** modes which are described in Table H.24

H.2.23.5
reset
action which provides reset from safe-state to allow the **system** to attempt a restart

H.2.23.6 Void

H.2.23.7
degradation (of performance)
undesired departure in the operational performance of any device, equipment or **system** from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent **failure**.

[SOURCE: IEC 60050-161:1990, 161-01-19]

H.2.23.8 Void

H.2.23.9
harm
physical injury or damage to health of people, or damage to property or the **environment**

[SOURCE: ISO/IEC Guide 51:1999, 3.3]

H.2.23.10
hazard
potential source of **harm**

[SOURCE: ISO/IEC Guide 51:1999, 3.5]

H.2.23.11
risk
combination of the probability of occurrence of **harm** and the severity of that **harm**

[SOURCE: ISO/IEC Guide 51:1999, 3.2]

H.2.23.12
reasonably foreseeable misuse
use of a product, process or service under conditions or for purposes not intended by the supplier, but which may happen, induced by the design of the product in combination with, or as result of, common human behaviour

[SOURCE: ISO/IEC Guide 51:1999, 3.14 modified, – "in a way not intended by the supplier, but which may result from readily predictable human behaviour" have been added.]

H.2.23.13
functional safety
safety related to the application which depends on the correct functioning of the safety-related **control**

H.2.24 Definitions related to access to data exchange

H.2.24.1
sequence number
additional data field containing a number that changes in a predefined way from message to message

H.2.24.2
time stamp
information concerning time of **transmission** attached to a message by the sender

H.2.24.3
source and destination identifier
identifier which is assigned to each entity

Note 1 to entry: This identifier can be a name, number or arbitrary bit pattern. This identifier will be used for the safety-related communication. Usually the identifier is added to the **user** data.

H.2.24.4
feed-back message
response from a receiver to the sender, via a return channel

H.2.24.5
identification procedure
procedure that forms a part of the safety-related application process

Note 1 to entry: Two types of **identification procedure** can be distinguished:

– bi-directional identification – Where a return communication channel is available, exchange of entity identifiers between senders and receivers of information can provide additional assurance that the communication is actually between the intended parties,

– dynamic **identification procedures** – Dynamic exchange of information between senders and receivers, including transformation and feedback of received information to the sender. Can provide assurance that the communicating parties not only claim to possess the correct identity, but also behave in the manner expected. This type of dynamic **identification procedure** can be used to preface the transmission of information between communicating safety-related processes and/or it can be used during the information transmission itself.

H.2.24.6
safety code
redundant data included in a safety-related message to permit data corruptions to be detected by the safety-related transmission function

H.2.24.7
cryptographic techniques
output data are calculated by an algorithm using input data and a key as a parameter

Note 1 to entry: By knowing the output data, it is impossible within a reasonable time to calculate the input data without knowledge of the key. It is also impossible within a reasonable time to derive the key from the output data, even if the input data are known.

H.2.24.8
time-out
delay between two messages exceeding a predefined allowed maximum time

NOTE 1 to entry: If this is the case, an error can be assumed.

A1 **H.2.24.9**
public network
data and signals not confined to the physical space within the household, or locations specified as being covered within the scope of this standard

Note 1 to entry: Examples of **public networks** include but are not limited to:

– Internet;
– Wi-Fi Devices;
– Bluetooth > 10 m Devices. A1

H.4 General notes on tests

H.4.1 Conditions of test

H.4.1.4 *Addition:*

*For **electronic controls**, the tests of Clauses H.25, H.26 and H.27 are carried out before the tests of Clause 21.*

Additional subclauses:

H.4.1.9 ***Electronic controls*** *shall be tested as **electrical controls**, unless otherwise specified.*

H.4.1.10 *When conducting the test sequence for **electronic controls**, care shall be taken that the results of a test are not influenced adversely by any preceding testing of the sample unless specifically required by the standard. It may be necessary to replace that sample, or parts thereof, or to use an additional sample.*

NOTE The number of samples can be kept to the minimum by an evaluation of the relevant circuits.

H.4.1.11 *Except for the test specified in Clause H.26, care shall be taken that the supply is free of such perturbations from external sources as may influence the results of the tests on **electronic controls**.*

H.6 Classification

H.6.4 According to features of automatic action

H.6.4.3 *Additional subclause:*

H.6.4.3.13 – **electronic disconnection** on **operation** (Type 1.Y – 2.Y)

H.6.9 According to circuit disconnection or interruption

Addition:

H.6.9.5 – electronic disconnection

H.6.18 According to classes of control functions (see Table 1, requirement 92)

H.6.18.1 – Control of class A control functions

H.6.18.2 – Control of class B control functions

H.6.18.3 – Control of class C control functions

H.7 Information

Additional items to Table 1 [m] *(1 of 2)*

Information		Clause or subclause	Method
Modification:		11.3.2, 〔C〉H.2.4.6,〈C〉 H.11.4.16, H.17.14, H.18.1.5, H.27.1.1, H.28	X
36	Limits of **activating quantity** for any **sensing element** over which **micro-disconnection** or **electronic disconnection** is secure		
Additional items to Table 1:			D
52	The minimum parameters of any heat dissipator (for example, heat sink) not provided with an **electronic control** but essential to its correct **operation**	14	
53	Type of output waveform if other than sinusoidal	H.25	X
54	Details of the **leakage current** waveform produced after **failure** of the **basic insulation**	H.27	X
55	The relevant parameters of those **electronic devices** or other circuit components considered as unlikely to fail (see paragraph 1 of H.27.1.1.4)	H.27	X
56	Type of output waveform(s) produced after **failure** of an **electronic device** or other circuit component (see item g) of H.27.1.1.3)	H.27	X
57	The effect on controlled output(s) after electronic circuit component **failure** if relevant (item c) of H.27.1.1.3)	H.27	X
58a	For integrated and incorporated **electronic controls**, if any protection against mains borne perturbations, magnetic and electromagnetic disturbances is claimed, which of the tests of Clause H.26 shall be performed and the effect on controlled output(s) and function after a **failure** to operate as a result of each test	H.26.2 H.26.15	X
58b	For other than integrated and incorporated **electronic controls**, the effect on controlled output(s) and function after a **failure** to operate as a result of the tests of Clause H.26	H.26.2 H.26.15	X
59	Any component on which reliance is placed for **electronic disconnection** which is disconnected as required by footnote n to Table 12	13.2 H.27.1	X
60	Installation class (surge immunity)	H.26.8.2 〔C〉 *Text deleted* 〈C〉	X
66	Software sequence documentation [m n o p]	H.11.12.2.9	X
67	Programme documentation [m q p]	H.11.12.2.9 H.11.12.2.12	X
68	Software **fault** analysis [m o p]	H.11.12 H.27.1.1.4	X
69	Software class(es) and structure [r] 〔A1〉 This information is not required for class A **controls** 〈A1〉	H.11.12.2 H.11.12.3 H.27.1.2.2.1 H.27.1.2.3.1	D
70	Analytical measures and **fault**/error control techniques employed [m s]	H.11.12.1.2	X

		H.11.12.2.2 H.11.12.2.4	
71	**Software fault/error detection time(s)** for **controls** with software classes B or C [m t]	H.2.17.10 H.11.12.2.6	X
72	**Control** response(s) in case of detected **fault**/error [m]	H.11.12.2.7	X
73	**Controls** subjected to a second **fault** analysis and declared condition as a result of the second **fault**	H.27.1.2.3	X
74	External load and emission control measures to be used for test purposes	H.23.1.1	X

Additional items to Table 1 (2 of 2)

Information	Clause or subclause	Method
91 Fault reaction time	H.2.23.2 H.27.1.2.2.2 H.27.1.2.2.3 H.27.1.2.3.2 H.27.1.2.3.3 H.27.1.2.4.2 H.27.1.2.4.3	X
92 Class or classes of **control** function(s)	H.6.18 H.27.1.2.2 H.27.1.2.3	X
93 Maximum number of **reset** actions within a time period	H.11.12.4.3.6 H.11.12.4.3.4	D
94 Number of remote **reset** actions	H.17.1.4.3	X

[m] For **controls** declared as entirely Class A, the requirements 66, 67, 68, 70, 71 and 72 are exempted. For **controls** with software classes B or C, information shall be provided only for the safety-related segments of the software. Information on the non-safety related segments shall be sufficient to establish that they do not influence the safety-related segments.

[n] The software sequence shall be documented and, together with the **operating sequence** of table requirement 46, shall include a description of the **control system** philosophy, the **control** flow, data flow and the timings.

[o] Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of 17, 25, 26 and 27, shall be identified. This identification shall include the **operating sequence** and may, for example, take the form of a **fault** tree analysis which shall include those **fault**/errors of Table H.1 which could result in non-compliance. The software **fault** analysis shall be related to the hardware **fault** analysis in Clause H.27.

[p] Examples of other information which may be suitable for inclusion in the documentation required by footnotes m, n, o, q, r and s are:

Original software system specification, for example:

- functional specification, including procedure for restart on loss of supply,
- module design, including description of equipment interfaces, and description of **user** interfaces,
- detailed design, including description of use of memory,
- code listing, including programming language identification, comments and listing of subroutines,
- test specification,
- manuals for installation, use and/or maintenance.

[q] Programming documentation shall be supplied in a programming design language declared by the manufacturer.

[r] Within a **control**, different software classes may apply to different **control** functions. Examples of **control** functions that may include software classes A to C are as follows:

Class A – Examples are room thermostats, humidity controls, lighting controls, timers and time switches.

Class B – An example is a thermal cut-out.

Class C – Examples are automatic burner **controls** and thermal cut-outs for closed water heater systems (unvented).

[s] Measures to be declared are those chosen by the manufacturer from the requirements of H.11.12.1.2 to H.11.12.2.4 inclusive.

[t] This can be expressed as a time following the execution of a specific software segment.

H.8 Protection against electric shock

H.8.1 General requirements

Additional subclauses:

H.8.1.10 Accessible parts shall not be considered as **hazardous live parts** if separated from the supply by **protective impedance**.

H.8.1.10.1 When **protective impedance** is used, the current between the part or parts and either pole of the supply source shall not exceed 0,7 mA (peak value) a.c. or 2 mA d.c;

– for frequencies exceeding 1 kHz, the limit of 0,7 mA (peak value) is multiplied by the value of the frequency in kHz but shall not exceed 70 mA (peak value);
– for voltages over 42,4 V (peak value) and up to and including 450 V (peak value), the capacitance shall not exceed 0,1 μF;
– for voltages over 450 V (peak value) and up to and including 15 kV (peak value), the product of the capacitance in farads times the potential in volts shall not exceed 45 μC;
– for voltages over 15 kV (peak value), the product of the capacitance in farads times the square of the potential in volts shall not exceed 350 mJ.

Compliance is checked by measurement.

*Voltages and currents are measured between a single **accessible part** (or any combination of such parts)* [A1] *and the protective earth conductor. Measurements shall be taken in normal supply configuration, and with supply poles interchanged.* [A1]

The measuring circuit shall have a total impedance of (1 750 ± 250) Ω and be shunted by a capacitor such that the time constant of the circuit is (225 ± 15) μs.

Details of a suitable measuring circuit are shown in Figure E.1.

The measuring circuit shall have an accuracy of within 5 % for all frequencies in the range of 20 Hz to 5 kHz. For frequencies above 5 kHz, alternative methods of measurement are required.

H.11 Constructional requirements

H.11.2 Protection against electric shock

Additional subclauses:

H.11.2.5 Protective impedance shall consist of two or more impedance components of equivalent resistance values in series, which are connected between **live parts** and **accessible parts**. It shall consist of components in which the probability of a reduction in impedance during life can be ignored and the possibility of a short circuit is negligible.

[A1] *The use of only one Y1 capacitor is permitted where the relevant safety characteristics of the capacitor are specified and controlled to be likely.*

NOTE This is in line with 5.3.4 of IEC 61140:2001. [A1]

Such components are

– *Resistors* [A1] *detailed* [A1] *in Table H.24, footnote c.*

Alternatively, the resistors shall comply with the requirements of 14.1 of IEC 60065:2001/AMD1:2005.

– *Capacitors.*

Capacitors shall comply with IEC 60384-14, class Y.

Under these conditions, the equipment shall still comply with the requirements of H.8.1.10.

H.11.4 Actions

Additional subclauses:

H.11.4.16 Type 1.Y or 2.Y action shall operate to provide **electronic disconnection**.

Compliance is checked by the tests of H.11.4.16.

H.11.4.16.1 The test is carried out with the **control** connected to its declared maximum load, supplied with rated voltage, and at temperature T_{max}.

H.11.4.16.2 The current through the **electronic disconnection** shall not exceed 5 mA or 10 % of the rated current, whichever is the lower.

H.11.12 Controls using software

Controls using software shall be so constructed that the software does not impair **control** compliance with the requirements of this standard.

*Compliance is checked by the tests for **electronic controls** in this standard, by **inspection** according to the requirements of H.11.12 and by examination of the documentation required in requirements 66 to 72 inclusive of Table 1.*

Subclauses H.11.12.1 to H.11.12.4 inclusive are only applicable to **control** functions using software class B or class C.

Subclause H.11.12.4 contains additional requirements for **remotely actuated control functions**.

H.11.12.1 Requirements for the architecture

H.11.12.1.1 Control functions with software class B or C shall use measures to control and avoid software-related **faults**/errors in safety-related data and safety-related segments of the software, as detailed in H.11.12.1.2 to H.11.12.3 inclusive.

H.11.12.1.2 Structure for control functions with software class B or C

H.11.12.1.2.1 Control functions with software class C shall have one of the following structures:

– **single channel with periodic self-test and monitoring** (H.2.16.7);

– **dual channel (homogenous) with comparison** (H.2.16.3);

– **dual channel (diverse) with comparison** (H.2.16.2).

NOTE Comparison between **dual channel** structures can be performed:

– by the use of a **comparator** (H.2.18.3) or

– by **reciprocal comparison** (H.2.18.15).

H.11.12.1.2.2 Control functions with software class B shall have one of the following structures:

– **single channel with functional test** (H.2.16.5);

– **single channel with periodic self-test** (H.2.16.6);

– **dual channel** without comparison (H.2.16.1).

A software class C structure is also acceptable for a software class B structure.

H.11.12.1.3 Other structures are permitted if they can be shown to provide an equivalent level of safety to those in H.11.12.1.2.

H.11.12.2 Measures to control faults/errors

H.11.12.2.1 When **redundant memory with comparison** is provided on two areas of the same component, the data in one area shall be stored in a different format from that in the other area (see **software diversity**).

H.11.12.2.2 Controls with software class C using **dual channel** structures with comparison shall have additional **fault**/error detection means (such as periodic functional tests, periodic self-tests, or **independent** monitoring) for any **fault**/errors not detected by the comparison.

H.11.12.2.3 For **controls** with software class B or C, means shall be provided for the recognition and control of errors in **transmissions** to external safety-related data paths. Such means shall take into account errors in data, addressing, **transmission** timing and sequence of protocol.

H.11.12.2.4 For **control** with software class B or C, the manufacturer shall provide, within the control, measures to address the **fault**/errors in safety-related segments and data indicated in Table H.1 and identified in Table 1, requirement 68.

Table H.1 (H.11.12.7 of edition 3) – Acceptable measures to address fault/errors [a] *(1 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
1. CPU					
1.1					
Registers	Stuck at	rq		Functional test, or	H.2.16.5
				periodic self-test using either:	H.2.16.6
				– **static memory test**, or	H.2.19.6
				– **word protection with single bit redundancy**	H.2.19.8.2
	DC **fault**		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**, or	H.2.18.3
				internal error detection, or	H.2.18.9
				redundant memory with comparison, or	H.2.19.5
				periodic self-tests using either	
				– **walkpat memory test**	H.2.19.7
				– **Abraham test**	H.2.19.1
				– **transparent GALPAT test**; or	H.2.19.2.1
				word protection with multi-bit redundancy, or	H.2.19.8.1
				static memory test and word protection	H.2.19.6
				with single bit redundancy	H.2.19.8.2
1.2					
Instruction decoding and execution	Wrong decoding and execution		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**, or	H.2.18.3
				internal error detection, or	H.2.18.9
				periodic self-test using **equivalence class test**	H.2.18.5
1.3				Functional test, or	H.2.16.5
Programme counter	Stuck at	rq		periodic self-test, or	H.2.16.6
				independent time-slot monitoring of the program sequence, or	H.2.18.10.4
				logical monitoring of the programme sequence	H.2.18.10.2
				Periodic self-test and monitoring using either:	H.2.16.7
	DC **fault**		rq	**– independent time-slot and logical monitoring**	H.2.18.10.3
				– **internal error detection**, or	H.2.18.9
				comparison of redundant functional channels by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**	H.2.18.3

Table H.1 *(2 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
1.4 Addressing	DC **fault**		rq	Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**; or **Internal error detection**; or periodic self-test using a **testing pattern** of the address lines; or **full bus redundancy**, or **multi-bit bus parity**	 H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.22 H.2.18.1.1 H.2.18.1.2
1.5 Data paths instruction decoding	DC **fault** and execution		rq	Comparison of redundant CPUs by either: **reciprocal comparison**, or **independent** hardware **comparator**, or **Internal error detection**, or periodic self-test using a **testing pattern**, or **data redundancy**, or **multi-bit bus parity**	 H.2.18.15 H.2.18.3 H.2.18.9 H.2.16.7 H.2.18.2.1 H.2.18.1.2
2. Interrupt handling and execution	No interrupt or too frequent interrupt	rq		Functional test; or time-slot monitoring	H.2.16.5 H.2.18.10.4
	No interrupt or too frequent interrupt related to different sources		rq	Comparison of redundant functional channels by either **reciprocal comparison**, **independent** hardware **comparator**, or **Independent time-slot and logical monitoring**	 H.2.18.15 H.2.18.3 H.2.18.10.3

Table H.1 *(3 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
3. Clock		rq		**Frequency monitoring**, or time slot monitoring	H.2.18.10.1 H.2.18.10.4
	Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only)		rq	**Frequency monitoring**, or time-slot monitoring, or comparison of redundant functional channels by either: – **reciprocal comparison** – **independent** hardware **comparator**	H.2.18.10.1 H.2.18.10.4 H.2.18.15 H.2.18.3
4. Memory 4.1 **Invariable memory**	All single bit **faults** 99,6 % coverage of all information errors	rq	rq	Periodic **modified checksum**; or **multiple checksum**, or **word protection with single bit redundancy** Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**, or **redundant memory with comparison**, or periodic cyclic redundancy check, either – single word – double word, or **word protection with multi-bit redundancy**	H.2.19.3.1 H.2.19.3.2 H.2.19.8.2 H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1
4.2 Variable memory	DC **fault** DC **fault** and dynamic cross links	rq	rq	Periodic **static memory test**, or **word protection with single bit redundancy** Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**, or **redundant memory with comparison**, or periodic self-tests using either: – **walkpat memory test** – **Abraham test** – **transparent GALPAT test**, or **word protection with multi-bit redundancy**	H.2.19.6 H.2.19.8.2 H.2.18.15 H.2.18.3 H.2.19.5 H.2.19.7 H.2.19.1 H.2.19.2.1 H.2.19.8.1

Table H.1 *(4 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
4.3 Addressing (relevant to **variable memory** and **invariable memory**)	Stuck at DC **fault**	rq	 rq	**Word protection with single bit redundancy** including the address, or comparison of redundant CPUs by either: – **reciprocal comparison**, or – **independent** hardware **comparator**, or **full bus redundancy** **Testing pattern**, or periodic cyclic redundancy check, either: – single word – double word, or **word protection with multi-bit redundancy** including the address	H.2.19.18.2 H.2.18.15 H.2.18.3 H.2.18.1.1 H.2.18.22 H.2.19.4.1 H.2.19.4.2 H.2.19.8.1
5. Internal data path 5.1 Data	 Stuck at DC **fault**	 rq	 rq	 **Word protection with single bit redundancy** Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**, or **word protection with multi-bit redundancy** including the address, or **data redundancy**, or **testing pattern**, or **protocol test**	 H.2.19.8.2 H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.2.1 H.2.18.22 H.2.18.14
5.2 Addressing	Wrong address Wrong address and multiple addressing	rq	 rq	**Word protection with single bit redundancy** including the address Comparison of redundant CPUs by: – **reciprocal comparison** – **independent** hardware **comparator**, or **word protection with multi-bit redundancy**, including the address, or **full bus redundancy**; or **testing pattern** including the address	H.2.19.8.2 H.2.18.15 H.2.18.3 H.2.19.8.1 H.2.18.1.1 H.2.18.22
6 External communication	**Hamming distance** 3	rq		**Word protection with multi-bit redundancy**, or **CRC – single word** , or **transfer redundancy**, or **protocol test**	H.2.19.8.1 H.2.19.4.1 H.2.18.2.2 H.2.18.14

Table H.1 *(5 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
6.1 Data	**Hamming distance** 4		rq	**CRC – double word**, or	H.2.19.4.2
				data redundancy or comparison of redundant functional channels by either:	H.2.18.2.1
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**	H.2.18.3
6.2 Addressing	Wrong address	rq		**Word protection with multi-bit redundancy**, including the address, or **CRC – single word** including the addresses, or	H.2.19.8.1 H.2.19.4.1
				transfer redundancy or	H.2.18.2.2
				protocol test	H.2.18.14
	Wrong and multiple addressing		rq	**CRC – double word**, including the address, or	H.2.19.4.2
				full bus redundancy of data and address, or	H.2.18.1.1
				comparison of redundant communication channels by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**	H.2.18.3
6.3 Timing	Wrong point in time	rq		Time-slot monitoring, or **scheduled transmission**	H.2.18.10.4 H.2.18.18
			rq	**Time-slot and logical monitoring**, or	H.2.18.10.3
				comparison of redundant communication channels by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**	H.2.18.3
	Wrong sequence	rq		Logical monitoring, or	H.2.18.10.2
				time-slot monitoring, or	H.2.18.10.4
				scheduled transmission	H.2.18.18
			rq	(same options as for wrong point in time)	
7. Input/output periphery	**Fault** conditions specified in Clause H.27	rq		**Plausibility check**	H.2.18.13
			rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.2.18.15
				– **independent** hardware **comparator**, or	H.2.18.3
7.1 Digital I/O				**input comparison**, or	H.2.18.8
				multiple parallel outputs; or	H.2.18.11
				output verification, or	H.2.18.12
				testing pattern, or	H.2.18.22
				code safety	H.2.18.2

Table H.1 *(6 of 6)*

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
7.2 Analog I/O 7.2.1 A/D- and D/A- convertor	**Fault** conditions specified in Clause H.27	rq	 rq	**Plausibility check** Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**, or **input comparison**, or **multiple parallel outputs**, or **output verification**, or **testing pattern**	H.2.18.13 H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.11 H.2.18.12 H.2.18.22
7.2.2 Analog multiplexer	Wrong addressing	rq	 rq	**Plausibility check** Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**, or **input comparison** or **testing pattern**	H.2.18.13 H.2.18.15 H.2.18.3 H.2.18.8 H.2.18.22
8. Monitoring devices and **comparators**	Any output outside the static and dynamic functional specification		rq	**Tested monitoring**, or **redundant monitoring** and comparison, or **error recognizing means**	H.2.18.21 H.2.18.17 H.2.18.6
9. Custom chips [f] for example, ASIC, GAL, Gate array	Any output outside the static and dynamic functional specification	rq	 rq	Periodic self-test Periodic self-test and monitoring, or **dual channel (diverse) with comparison**, or **error recognizing means**	H.2.16.6 H.2.16.7 H.2.16.2 H.2.18.6

CPU: Central programmation unit

rq: Coverage of the **fault** is required for the indicated software class.

[a] Table H.1 is applied according to the requirements of H.11.12 to H.11.12.2.12 inclusive.

[b] For **fault**/error assessment, some components are divided into their subfunctions.

[c] For each subfunction in the table, the software class C measure will cover the software class B **fault**/error.

[d] It is recognized that some of the acceptable measures provide a higher level of assurance than is required by this standard.

[e] Where more than one measure is given for a subfunction, these are alternatives.

[f] To be divided as necessary by the manufacturer into subfunctions.

H.11.12.2.5 Measures others than those specified in H.11.12.2.4 are permitted if they can be shown to satisfy the requirements listed in Table H.1.

H.11.12.2.6 Software **fault**/error detection shall occur not later than the time declared in requirement 71 of Table 1. The acceptability of the declared time(s) is evaluated during the **fault** analysis of the **control**.

Part 2 standards may limit this declaration.

H.11.12.2.7 For **controls** with functions, classified as Class B or C, detection of a **fault**/error shall result in the response declared in Table 1, requirement 72. For **controls** with functions declared as class C, **independent** means capable of performing this response shall be provided.

H.11.12.2.8 The loss of **dual channel** capability is deemed to be an error in a **control** function using a **dual channel** structure with software class C.

H.11.12.2.9 The software shall be referenced to relevant parts of the **operating sequence** and the associated hardware functions.

H.11.12.2.10 Where labels are used for memory locations, these labels shall be unique.

H.11.12.2.11 The software shall be protected from **user** alteration of safety-related segments and data.

H.11.12.2.12 The software and safety-related hardware under its control shall be initialized to, and terminate at, a declared state as indicated in Table 1, requirement 66.

H.11.12.3 Measures to avoid errors

〖A1〗 Void.〖A1〗

H.11.12.3.1 General

For **controls** with software class B or C the measures shown in Figure H.1 to avoid systematic **faults** shall be applied.

Measures used for software class C are inherently acceptable for software class B.

The content of this is extracted from IEC 61508-3 and adapted to the needs of this standard.

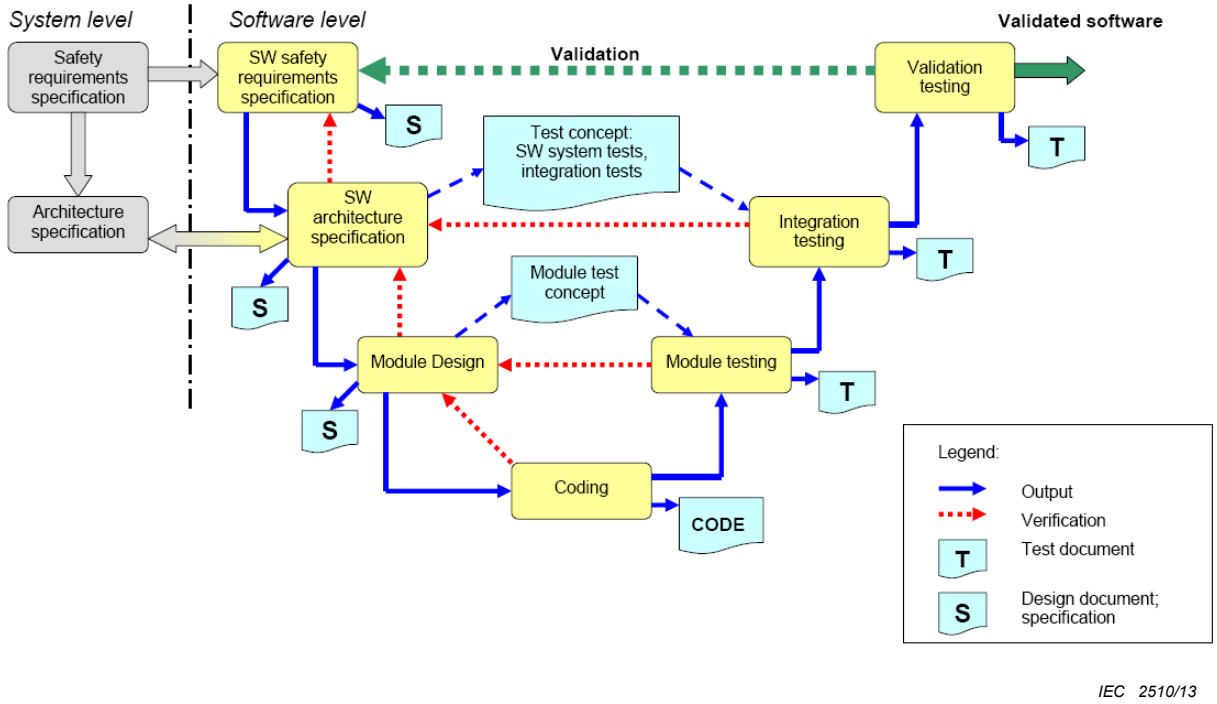


Figure H.1 – V-Model for the software life cycle

Other methods are possible if they incorporate disciplined and structured processes including design and test phases.

H.11.12.3.2 Specification

H.11.12.3.2.1 Software safety requirements

H.11.12.3.2.1.1 The specification of the software safety requirements shall include:

– a description of each safety related function to be implemented, including its response time(s):
  - functions related to the application including their related software classes;
  - functions related to the detection, annunciation and management of software or hardware **faults**;
– a description of interfaces between software and hardware;
– a description of interfaces between any safety and non-safety related functions.

Examples of techniques/measures can be found in Table H.2.

Table H.2 – Semi-formal methods

Technique/Measure	References (informative)
Standards identification	
Semi-formal methods – Logical/functional block diagrams – Sequence diagrams – Finite state machines/state transition diagrams – Decision/truth tables	B.2.3.2 of IEC 61508-7:2010 C.6.1 of IEC 61508-7:2010

Other methods to comply with the requirements can be applied.

H.11.12.3.2.2 Software architecture

H.11.12.3.2.2.1 The description of software architecture shall include the following aspects:

– techniques and measures to control software **faults**/errors (refer to H.11.12.2);
– interactions between hardware and software;
– partitioning into modules and their allocation to the specified safety functions;
– hierarchy and call structure of the modules (**control** flow);
– interrupt handling;
– data flow and restrictions on data access;
– architecture and storage of data;
– time based dependencies of sequences and data.

Examples of techniques/measures can be found in Table H.3.

Table H.3 – Software architecture specification

Technique/Measure	References (informative)
Fault detection and diagnosis	C.3.1 of IEC 61508-7:2010
Semi-formal methods:	
− Logic/function block diagrams	
− Sequence diagrams	
− Finite state machines/state transition diagrams	B.2.3.2 of IEC 61508-7:2010
− Data flow diagrams	C.2.2 of IEC 61508-7:2010

H.11.12.3.2.2.2 The architecture specification shall be verified against the specification of the software safety requirements by static analysis.

NOTE Acceptable methods for **static analysis** are:

– **control** flow analysis;
– data flow analysis;
– **walk-throughs**/design reviews.

H.11.12.3.2.3 Module design and coding

NOTE 1 The use of computer aided design tools is accepted.

NOTE 2 For Defensive Programming (for example, range checks, check for division by 0, **plausibility checks**), see C.2.5 of IEC 61508-7:2010.

H.11.12.3.2.3.1 Based on the architecture design, software shall be suitably refined into modules. Software module design and coding shall be implemented in a way that is traceable to the software architecture and requirements.

The module design shall specify:

– function(s),
– interfaces to other modules,
– data.

Examples of techniques/measures can be found in Table H.4.

Table H.4 – Module design specification

Technique/Measure	References (informative)
Limited size of software modules	C.2.9 of IEC 61508-7:2010
Information hiding/encapsulation	C.2.8 of IEC 61508-7:2010
One entry/one exit point in subroutines and functions	C.2.9 of IEC 61508-7:2010
Fully defined interface	C.2.9 of IEC 61508-7:2010
Semi-formal methods:	
– Logic/function block diagrams	
– Sequence diagrams	
– Finite state machines/state transition diagrams	B.2.3.2 of IEC 61508-7:2010
– Data flow diagrams	C.2.2 of IEC 61508-7:2010

H.11.12.3.2.3.2 Software code shall be structured.

NOTE Structural complexity can be minimized by applying the following principles:

– keep the number of possible paths through a software module small, and the relation between the input and output parameters as simple as possible;

– avoid complicated branching and, in particular, avoid unconditional jumps (GOTO) in higher level languages;

– where possible, relate loop constraints and branching to input parameters;

– avoid using complex calculations as the basis of branching and loop decisions.

Examples of techniques/measures can be found in Table H.5.

Table H.5 – Design and coding standards

Technique/Measure	References (informative)
Use of coding standard (see H.11.12.3.2.4)	C.2.6.2 of IEC 61508-7:2010
No use of dynamic objects and variables (see Note)	C.2.6.3 of IEC 61508-7:2010
Limited use of interrupts	C.2.6.5 of IEC 61508-7:2010
Limited use of pointers	C.2.6.6 of IEC 61508-7:2010
Limited use of recursion	C.2.6.7 of IEC 61508-7:2010
No unconditional jumps in programs in higher level languages	C.2.6.2 of IEC 61508-7:2010
Dynamic objects and/or variables are allowed if a compiler is used which ensures that sufficient memory for all dynamic objects and/or variables will be allocated before runtime, or which inserts runtime checks for the correct online allocation of memory.	

H.11.12.3.2.3.3 Coded software shall be verified against the module specification, and the module specification shall be verified against the architecture specification by static analysis.

NOTE Examples of methods for **static analysis** are:

– **control** flow analysis;

– data flow analysis;

– **walk-throughs**/design reviews.

H.11.12.3.2.4 Design and coding standards

Program design and coding standards shall be consequently used during software design and maintenance.

Coding standards shall specify programming practice, proscribe unsafe language features, and specify procedures for source code documentation as well as for data naming conventions.

H.11.12.3.3 Testing

H.11.12.3.3.1 Module design (software system design, software module design and coding)

H.11.12.3.3.1.1 A test concept with suitable test cases shall be defined based on the module design specification.

H.11.12.3.3.1.2 Each software module shall be tested as specified within the test concept.

H.11.12.3.3.1.3 Test cases, test data and test results shall be documented.

H.11.12.3.3.1.4 Code verification of a software module by static means includes such techniques as software **inspections**, **walk-throughs**, **static analysis** and formal proof.

Code verification of a software module by dynamic means includes functional testing, white-box testing and statistical testing.

It is the combination of both types of evidence that provides assurance that each software module satisfies its associated specification.

Examples of techniques/measures can be found in Table H.6.

Table H.6 – Software module testing

Technique/Measure	References (informative)
Dynamic analysis and testing:	B.6.5 of IEC 61508-7:2010
– Test case execution from boundary value analysis	C.5.4 of IEC 61508-7:2010
– Structure-based testing	C.5.8 of IEC 61508-7:2010
Data recording and analysis	C.5.2 of IEC 61508-7:2010
Functional and black-box testing:	B.5.1, B.5.2 of IEC 61508-7:2010
– Boundary value analysis	C.5.4 of IEC 61508-7:2010
– Process simulation	C.5.18 of IEC 61508-7:2010
Performance testing:	C.5.20 of IEC 61508-7:2010
– Avalanche/stress testing	C.5.21 of IEC 61508-7:2010
– Response timings and memory constraints	C.5.22 of IEC 61508-7:2010
Interface testing	C.5.3 of IEC 61508-7:2010

NOTE Software module testing is a verification activity.

H.11.12.3.3.2 Software integration testing

H.11.12.3.3.2.1 A test concept with suitable test cases shall be defined based on the architecture design specification.

H.11.12.3.3.2.2 The software shall be tested as specified within the test concept.

H.11.12.3.3.2.3 Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found Table H.7.

Table H.7 – Software integration testing

Technique/Measure	References (informative)
Functional and black-box testing:	B.5.1, B.5.2 of IEC 61508-7:2010
– Boundary value analysis	C.5.4 of IEC 61508-7:2010
– Process simulation	C.5.18 of IEC 61508-7,
Performance testing:	C.5.20 of IEC 61508-7:2010
– Avalanche/stress testing	C.5.21 of IEC 61508-7:2010
– Response timings and memory constraints	C.5.22 of IEC 61508-7:2010

NOTE Software integration testing is a verification activity.

H.11.12.3.3.3 Software validation

H.11.12.3.3.3.1 A validation concept with suitable test cases shall be defined based on the software safety requirements specification.

H.11.12.3.3.3.2 The software shall be validated with reference to the requirements of the software safety requirements specification as specified within the validation concept.

The software shall be exercised by simulation or stimulation of

– input signals present during normal **operation**,
– anticipated occurrences,
– undesired conditions requiring **system** action.

H.11.12.3.3.3.3 Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found in Table H.8.

Table H.8 – Software safety validation

Technique/Measure	References (informative)
Functional and black-box testing:	B.5.1, B.5.2 of IEC 61508-7:2010
– Boundary value analysis	C.5.4 of IEC 61508-7:2010
– Process simulation	C.5.18 of IEC 61508-7:2010
Simulation, modeling:	
– Finite state machines	B.2.3.2 of IEC 61508-7:2010
– Performance modeling	C.5.20 of IEC 61508-7:2010

NOTE Testing is the main validation method for software; modelling can be used to supplement the validation activities.

H.11.12.3.4 Other Items

H.11.12.3.4.1 Tools, programming languages

Equipment used for software design, verification and maintenance, such as design tools, programming languages, translators and test tools, shall be qualified appropriately, and shall be shown to be suitable for purpose in manifold applications.

They are assumed to be suitable if they comply with "increased confidence from use" according to C.4.4 of IEC 61508-7:2010.

H.11.12.3.4.2 Management of software versions

A software version management system at the module level shall be put in place. All versions shall be uniquely identified for traceability.

H.11.12.3.4.3 Software modification

H.11.12.3.4.3.1 Software modifications shall be based on a modification request which details the following:

– the **hazards** which may be affected,

– the proposed change,

– the reasons for change.

H.11.12.3.4.3.2 An analysis shall be carried out to determine the impact of the proposed modification on **functional safety**.

H.11.12.3.4.3.3 A detailed specification for the modification shall be generated including the necessary activities for verification and validation, such as a definition of suitable test cases.

H.11.12.3.4.3.4 The modification shall be carried out as planned.

H.11.12.3.4.3.5 The assessment of the modification shall be carried out based on the specified verification and validation activities. This may include:

– a reverification of changed software modules;

– a reverification of affected software modules;

– a revalidation of the complete **system**.

H.11.12.3.4.3.6 All details of modification activities shall be documented.

H.11.12.3.5 For **class C control functions**, the manufacturer shall have used one of the combinations (a–p) of analytical measures given in the columns of Table H.9 during hardware development.

Table H.9 (H.11.12.6 of edition 3) – Combinations of analytical measures during hardware development

Hardware development stage		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
H.2.17.5	**Inspection**	x		x		x		x		x		x		x		x	
H.2.17.9	**Walk-through**				x		x		x		x		x		x		x
H.2.17.7.1	**Static analysis**	x	x							x	x						
H.2.17.1	**Dynamic analysis**			x	x							x	x				
H.2.17.3	**Hardware analysis**					x	x							x	x		
H.2.17.4	**Hardware simulation**							x	x							x	x
H.2.17.2	**Failure rate calculation**	x	x	x	x	x	x	x	x								
H.2.20.2	**FMEA**									x	x	x	x	x	x	x	x
H.2.17.6	**Operational test**	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

H.11.12.4 Remotely actuated control functions

H.11.12.4.1 Data exchange

H.11.12.4.1.1 General

Remotely actuated control functions may be connected to separate, **independent** devices, which may themselves contain **control** functions or provide other information. Any data exchange between these devices shall not compromise the integrity of **class B control function** or **class C control function**.

H.11.12.4.1.2 Type of data

Message types for data exchange in a **control** function or functions shall be allocated to **class A control function**, **class B control function** or **class C control function**. Regarding the safety or protective relevance or influence, message types or data exchange shall be allocated only to **class B control function** or **class C control functions**, see Table H.10.

Table H.10 – Data exchange

Data	Safety relevant	Non safety relevant
Operating data	Messages such as “RESET from safe state”	Messages such as on/off instructions, room temperature information
Configuration parameters	Messages modifying parameters that determine related **class B control function** or **class C control function**	Messages modifying parameters that determine performance related functions
Software modules	Modules downloaded into a system, that determine related **class B control function** or **class C control function**	Modules downloaded into a system, that determine performance related functions

H.11.12.4.1.3 Communication of safety related data

H.11.12.4.1.3.1 Transmission

Safety relevant data shall be transmitted authentically concerning:

– data corruption;
– address corruption;
– wrong timing or sequence.

Data variation or corrupted data shall not lead to an unsafe state. Before the use of transmitted data, it shall be ensured that the above items are addressed using the measures as given in Annex H of the same or higher software class used by that function.

Compliance is checked by assessment according to Annex H.

NOTE 1 Special attention is drawn to Table H.1, component 6, with regard to the following items:
- data deletion from the original message;
- data insertion into the original message;
- corruption of the data in the original message;
- change in sequence of data in the original message;
- make a non-authentic message look like an authentic message;
- incomplete address;
- corruption of the address of the original message;
- wrong address;
- more addresses;
- receive message more than once;
- delay in transmitting or receiving the message;
- wrong sequence of sending/receiving.

In addition to the items in Note 1, the following **failure** modes shall be addressed:

– permanent “auto-sending” or repetition,
– interruption of data transfer.

NOTE 2 Additional examples of measures are given in Table H.11.

H.11.12.4.1.3.2 Access to data exchange

All types of access to **class B control function** or **class C control function** related data exchange systems shall be clearly restricted.

For **class B control function** or **class C control function** related operating data, configuration parameters and/or software modules are allowed to be transmitted via communication, if adequate hardware/software measures are taken to prevent unauthorized access to the **control** function. Examples of which are given in Table H.11.

For access to data exchange of **class B control function** or **class C control function** related operating data through **public networks**, appropriate **cryptographical techniques** shall be implemented. See H.11.12.4.5.

NOTE Aspects concerning security are found under the work of ISO/IEC JTC 1/SC 27 (TC 205).

Table H.11 – Examples of defences against unauthorised access and transmission failure modes

	Defences							
Threats	**Sequence number**	**Time stamp**	**Time-out**	**Feedback message**	**Sourced destination identifier**	**Identification procedure**	**Safety code**	**Cyrpto-graphic techniques**
Repetition of a message	x	x						
Deletion of data in message	x							
Insertion of data in message	x			x	x	x		
Changed sequence of data in message	x	x						
Corrupted data in message							X [a]	x
Delay in sending / receiving the message		x	x					
Masquerade, making an inauthentic message look like an authentic message				x		x		x
Examples of defences against unauthorized access can also be found in the applications covered by EN 50159 (2011).								
[a] See Table H.1, items 6.1 and 6.2.								

H.11.12.4.1.3.3 Revision of Class B and Class C software

Requirements of H.11.12.3 shall apply to class B and class C software revisions. In addition, hardware configuration management shall be required, and measures shall be taken to ensure the **control** maintains its protective functions in accordance with this standard.

NOTE Hardware configuration management is meant to be in addition to software verification in order to maintain the integrity of the **control**. **System** level implications are taken into consideration.

H.11.12.4.1.4 For **remotely actuated control function operation**, the duration or limits of **operation** shall be set before switching on, unless an automatic switching off is realized at the end of a cycle or the **system** is designed for permanent **operation**.

*Compliance is checked by software **inspection**.*

H.11.12.4.2 Care shall be taken that priority over **control** functions shall not lead to a hazardous condition.

*Compliance is checked by **inspection**.*

H.11.12.4.3 Remote reset action

H.11.12.4.3.1 The remote **reset** action shall be manually initiated. When the **reset** function is initiated by a hand-held device at least two **manual** actions are required to activate a reset.

NOTE The two **manual actions** are considered to be discrete and separate.

H.11.12.4.3.2 **Reset** functions shall be capable of resetting the **system** as intended.

H.11.12.4.3.3 Unintended **resets** from safe state shall not occur.

H.11.12.4.3.4 Any **fault** of the **reset** function shall not cause the **control** or controlled function to result in a hazardous condition, and shall be evaluated for its Class B classification.

H.11.12.4.3.5 For **reset** functions initiated by **manual action** not in visible sight of the appliance, the following additional requirements apply:

– the actual status and relevant information of the process under control shall be visible to the **user** before, during and after the **reset** action;
– the maximum number of **reset** actions within a time period shall be declared (for example, 5 actions within a time span of 15 min). Following this, any further **reset** shall be denied unless the appliance is physically checked.

H.11.12.4.3.6 Consideration for the evaluation of reset functions on the final application

The **reset** function shall be evaluated on the final application.

NOTE Not all types of remote **reset** functions may be found suitable for some applications.

If the **reset** is activated by manual switching of a **thermostat** or device with similar function, this shall be declared by the manufacturer and be suitable in the final application.

A1 H.11.12.4.4 Software download and installation

H.11.12.4.4.1 Software updates provided by the manufacturer and transmitted to the **control** via remote communication shall be checked prior to its use:

– against corruption through communication ensuring **Hamming distance** 3 for software class B, or **Hamming distance** 4 for software class C. (Refer to Table H.1 for external communication.);
– if the software version is compatible with the hardware version of the **control** according to the version management documentation.

Additionally, the software which performs the above mentioned checks shall contain measures to control the **fault**/error conditions specified in H.11.12.2.

H.11.12.4.4.2 In case of software download via remote communication, the **cryptographic techniques** in H.11.12.4.5 shall be provided. In addition to the requirements in H.11.12.4.5, **identification procedures** shall also be provided for the software packages. A1

The **cryptographic techniques** employed shall be part of the **control**, and not rely upon part of the router or similar data **transmission** device itself, and shall be performed prior to **transmission**.

H.11.12.4.4.3 For each update of software, the **control** shall have provisions for authorization by the **user** and a version ID number which shall be accessible.

H.11.12.4.4.4 The installation of class B software or class C software is permitted when during and after the software installation process the **control** remains in compliance with the requirements of this standard.

*Compliance is checked by software **inspection**.*

H.11.12.4.5 Cryptographical techniques

In cases where **class B control function** or **class C control function** related operating data, configuration parameters and/or software modules are transmitted over a **public network**, and/or where software updates are provided by the manufacturer via remote communication, **cryptographic techniques** shall be employed.

*Compliance is checked by software **inspection** and review of technical documentation which provides adherence to the commonly accepted data integrity protection methods.*

NOTE Examples of commonly accepted **cryptographic techniques** are defined and described in ISO/IEC 9796, ISO/IEC 9797, ISO/IEC 9798, ISO/IEC 10118, ISO/IEC 11770, ISO/IEC 14888, ISO/IEC 15946, ISO/IEC 18033, ISO/IEC 29192, as well as ISO/IEC 19772.

H.17 Endurance

H.17.1 General requirements

H.17.1.4 No endurance test is carried out on **electronic controls** with **type 1 action** unless this is necessary for the testing of associated components such as those with **manual actions**, relays, etc.

H.17.1.4.1 Electronic controls with **type 2 action** are not subjected to an endurance test but to a thermal cycling test under the conditions described in H.17.1.4.2. This test may be combined with the testing of any associated components such as those with **manual actions**, relays, etc., if this is possible.

H.17.1.4.2 Thermal cycling test

The purpose of the test is to cycle components of an electronic circuit between the extremes of temperature likely to occur during **normal use** and which may result from ambient temperature variation, mounting surface temperature variation, supply voltage variation, or the change from an operating condition to a non-operating condition and vice versa.

The tests necessary to achieve the above conditions will depend to a large extent on the particular type of **control** and will be expanded upon, if necessary, in the appropriate part 2 of this standard.

The following conditions shall form the basis of the test:

a) Duration

*14 days, or any duration specified in the relevant part 2, whichever is the greater. For **controls** providing **electronic disconnection** (type 2.Y), 14 days, or the number of cycles declared in requirements 26 and 27 of Table 1, whichever produces the longer duration of test.*

b) Electrical conditions

*The **control** shall be loaded according to the ratings declared by the manufacturer, the voltage then being increased to 1,1 V_R except for 30 min of each 24 h period of the test when the voltage is reduced to 0,9 V_R. The change of voltage shall not be synchronized with the change of temperature. Each 24 h period shall also include at least one period in the order of 30 s during which the supply voltage is switched off.*

c) Thermal conditions

The ambient temperature and/or the mounting surface temperature are varied between T_{max} ($T_{S\ max}$) and T_{min} ($T_{S\ min}$) to cause the temperature of the components of the electronic circuit to be cycled between the resulting extremes. The rate of ambient and/or mounting surface temperature change shall be in the order of 1 K/min and the extremes of temperature maintained for approximately 1 h.

*d) Rate of **operation***

*During the test, the **control** shall be cycled through its operational modes at the fastest rate possible up to a maximum of six cycles per minute, subject to the need to cycle components between their temperature extremes.*

*If an operational mode, such as speed control, can be set by the **user**, the test period shall be divided into three periods, one period being at the maximum, one at the minimum and one at an intermediate **setting**.*

*For **controls** providing **electronic disconnection** (type 2.Y), the test also includes the declared number of **operations** from the conducting to the non-conducting state and vice versa.*

H.17.1.4.3 Controls with remote reset actions

*Independently mounted devices performing remote **reset** functions shall be tested for a minimum 1 000 **reset** actions. For integrated and incorporated devices, unless otherwise specified, the minimum **reset** cycles shall be declared by the manufacturer. After the test, the **reset** device shall be capable to **reset** the **system** as intended. Unintended **resets** shall not occur.*

H.17.14 Evaluation of compliance

Replacement of first paragraph:

*After all the appropriate tests of 17.6 to 17.13 inclusive and H.17.1.4, modified as specified in the appropriate part 2, the **control** shall be deemed to comply if:*

Additional dashed paragraph:

– for **controls** providing **electronic disconnection** (type 1.Y or 2.Y), the requirements of H.11.4.16 are still met.

H.18 Mechanical strength

H.18.1 General requirements

H.18.1.5 *Addition:*

For **controls** providing **electronic disconnection** (type 1.Y or 2.Y), the requirements of H.11.4.16 shall be met.

H.20 Creepage distances, clearances and distances through insulation

H.20.1 *Additional subclauses:*

H.20.1.15 Electronic controls

H.20.1.15.1 Creepage distances, **clearances** and distances through insulation between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of Clause 20.

H.20.1.15.2 Creepage distances, **clearances** and distances through insulation shall comply:

– across **protective impedance** with the requirements of Clause 20 for **double insulation** or **reinforced insulation**;
– across each separate component of **protective impedance** with the requirements of Clause 20 for **supplementary insulation**.

H.20.1.15.3 Creepage distances and **clearances** providing **functional insulation** shall comply with the requirements of Clause 20.

H.23 Electromagnetic compatibility (EMC) requirements – Emission

Equipment that uses integrated or **incorporated controls** should comply with its relevant product EMC standard. Integrated and **incorporated controls** are tested in the end use equipment.

H.23.1 Electronic controls shall be so constructed that they do not emit excessive electric or electromagnetic disturbances in their **environment**.

H.23.1.1 Low frequency emission, disturbances in supply systems

Integrated and **incorporated controls** are not subjected to the tests of this clause, as the results of these tests are influenced by the incorporation of the **control** into the equipment and the use of measures to control emissions used therein. They may, however, be carried out under declared conditions if so requested by the manufacturer.

Controls in which an **electronic device** controls directly an external load connected to the mains power supply (the **control** port) shall comply with the requirements of IEC 61000-3-2 and IEC 61000-3-3. For these tests, a load and measures to control emissions, if any, shall be used as declared by the manufacturer in requirement 74 of Table 1. This requirement does not apply to **controls** declared and designed for **pilot duty** load only.

H.23.1.2 Radio frequency emission

Free-standing, **independently mounted** and **in-line cord electronic controls** using telecommunication ports, software, oscillating circuits, or switching power supplies shall comply with the requirements of CISPR 14-1 and/or CISPR 22, class B, as indicated in Table H.12.

NOTE 1 Telecommunication port is defined in 3.6 of CISPR 22:2008.

Controls for ISM equipment and **free-standing**, **independently mounted** and **in-line cord controls** for use with ISM equipment shall comply with the requirements of CISPR 11.

Additional details may be given in the relevant part 2.

NOTE 2 The relevant part 2 will indicate whether the requirements of this clause apply to integrated and incorporated **electronic controls**.

Table H.12 (H.23 of edition 3) – Emission

Port	Frequency range	Limits	Basic standard	Applicability note	Remarks
Enclosure	30 MHz to 230 MHz 230 MHz to 1 000 MHz Above 1 GHz	30 dB(μV/m) at 10 m 37 dB(μV/m) at 10 m See Note 3	CISPR 22 Class B	See Note 1 See Note 3	The statistical evaluation in the basic standard applies
AC mains	0 kHz to 2 kHz		IEC 61000-3-2 IEC 61000-3-3	See Note 2	
	0,15 MHz to 0,5 MHz Limits decrease linearly with log. frequency	66 dB(μV) to 56 dB(μV) quasi peak 56 dB(μV) to 46 dB(μV) average	CISPR 22 Class B		The statistical evaluation in the basic standard applies
	0,5 MHz to 5 MHz	56 dB(μV) quasi peak 46 dB(μV) average			
	5 MHz to 30 MHz	60 dB(μV) quasi peak 50 dB(μV) average			
Load terminals	0,15 MHz to 30 MHz	See basic standard Clause: discontinuous interference	CISPR 14-1		

NOTE 1 Applicable only to **controls** containing processing devices, for example, microprocessors operating at frequencies greater than 9 kHz.

NOTE 2 Applicable only to equipment within the scope of IEC 61000-3-2 and IEC 61000-3-3. Limits for **controls** not currently covered by IEC 61000-3-2 and IEC 61000-3-3 are under consideration.

NOTE 3 Limits and applicability, see 6.2 of CISPR 22:2008.

H.25 Normal operation

H.25.1 The output waveform of **electronic controls** shall be as declared.

*The output waveform of the **control** shall be examined under all normal operating conditions and shall be either sinusoidal or as declared in Table 1, requirement 53.*

NOTE Attention is drawn to IEC 61000-3-2 and 61000-3-3, which impose restriction on mains disturbances.

H.26 Electromagnetic compatibility (EMC) requirements – Immunity

H.26.1 Electronic controls shall be so constructed as to withstand the effects of mains-borne perturbations and electromagnetic phenomena which may occur in **normal use**. For **type 2 controls** the tests of Clause H.26 are also carried out after the **control** has performed its safety function.

*Evaluation criteria for the **control** appropriate to test level 2 and/or 3 shall be given by the appropriate part 2. Refer to all subclauses in H.26.15 for additional details. These test levels correspond with test levels specified by the IEC 61000 series. The part 2 shall provide acceptable effects, assessment criteria, on the **control** as a result of tests using test levels 2 and/or 3, such as normal **operation** after test level 2 test and safe **operation** of appliance/safe shut-down after test level 3 test. Parts 2 may specify higher test levels.*

*The part 2 shall specify test levels for Clause H.26 tests. As a minimum, test level 3 is applicable to **protective controls** intended to prevent unsafe **operation** of the controlled equipment, such as cut-outs and door-locks for laundry equipment, and burner **controls**. As a minimum, test level 2 is applicable to **operating controls** relied on for the normal **operation** of the equipment, such as **thermostats**, **timers**.*

*The tests of Clause H.26 are not applicable to non-electronic **controls** because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic **controls** may be included in other clauses of the appropriate part 2.*

〚C〛 For EMC immunity of **operating controls** of **Type 1 action** intended to be used as "**free standing controls, independently mounted and/or in-line cord controls**", the tests of Annex ZD apply instead of those of Clause H.26. 〚C〛

H.26.2 *Compliance is checked at test levels as indicated by the following Table H.13. The **controls** shall comply with H.26.15.*

Table H.13 (H.26.2.1 of edition 3) – Applicable test levels

Control type	Type action	Applicable Clause H.26 tests	Applicable test levels corresponding to H.26.15.3 [a]
Operating control	**Type 1**	H.26.8, H.26.9	2
Operating control	**Type 2**	H.26.4 to H.26.14	2, 3, or 4 as specified
Protective control	**Type 2**	H.26.4 to H.26.14	3
Protective controls declared in Table 1, requirement 90 intended for use in accordance with IEC 60335-1	**Type 2**	H.26.4 to H.26.14	Applicable test levels according to 19.11.4 of IEC 60335-1:2010
[a] Lower test levels shall be considered in accordance with IEC 61000-4 series.			

H.26.2.1 *For integrated and **incorporated controls** with **type 1 action**, compliance is checked by the tests of H.26.8 and H.26.9 if declared in Table 1, requirement 58a.*

H.26.2.2 *For integrated and **incorporated controls** with **type 2 action**, compliance is checked by H.26.5 and any other tests of Clause H.26 which are declared in Table 1, requirement 58a.*

NOTE The suitability of each test in Clause H.26 to a given **control** can be determined by reference to the appropriate appliance standard(s) or to the manufacturer's declaration of the intended use of the **control**.

This determination of suitability includes an assessment:

– whether the **control** will be exposed to a particular type of disturbance in its application;

– whether the response of the **control** to the particular type of disturbance is relevant to safety in its application.

H.26.3 *A separate sample, as submitted, may be used for each test. At the option of the **control** manufacturer, multiple tests may be performed on a single sample.*

H.26.4 Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests

*For protective **controls** declared according to requirement 90 of Table 1, the following test applies:*

*The **control** is subjected to mains signals in accordance with IEC 61000-4-13, test level class 2 being applicable.*

*During the test the **control** is supplied with rated voltage. The test levels for Class 2 environment according to Tables 1 to 4 of IEC 61000-4-13:2002 shall be applied at the a.c. power port of the EUT. The **control** is tested under the test conditions as specified in the specific **control** standard.*

The following tests are performed in accordance with Figure 1a of IEC 61000-4-13:2002, Amendement 1:2009, for Class 2 environment:

– *"Harmonic combination" (see 8.2.1 of IEC 61000-4-13:2002, Amendement 1:2009);*
– *"Meister curve" (see 8.2.4 of IEC 61000-4-13:2002, Amendement 1:2009).*

H.26.5 Voltage dips, voltage interruptions and voltage variations in the power supply network

The **control** shall tolerate voltage dips voltage interruptions and voltage variations in the power supply network.

Compliance is checked by the tests of H.26.5.1 to H.26.5.2 inclusive.

H.26.5.1 Voltage dips and interruptions

The purpose of the test is to verify the immunity of the equipment against voltage dips and voltage interruptions. Voltage dips and interruptions are caused by **faults** in the LV, MV, HV networks (short-circuit or ground **faults**).

H.26.5.1.1 Test levels for voltage dips and interruptions

The test values in Table H.14 shall be applied to all the test levels.

Table H.14 – Voltage dips, short interruptions and voltage variations

Duration	ΔU		
	30 %	60 %	100 %
Half-cycle of supply waveform			X
One cycle of supply waveform			X
2,5 cycles	X	X	X
25 cycles	X	X	X
50 cycles	X	X	X
NOTE Where intermediate durations of voltage interruption may affect either the inherent safety of the **control** or the output of a type 2 **control**, parts 2 may indicate voltage interruptions at other points.			

H.26.5.1.2 Test procedure for voltage dips and interruptions

The test apparatus and procedures shall be as described in IEC 61000-4-11. During the test, the **control** shall be initially operated at its rated voltage.

The voltage dips and interruptions, at random phase with respect to the mains frequency, shall be performed at least three times in the relevant operating modes.

Attention should be given to the operating modes in which the **control** may be particularly sensitive to voltage dips and interruptions.

Between the voltage dips and interruptions a waiting time of at least 10 s shall be observed.

In the case of three-phase equipment, it may be necessary to apply voltage dips and interruptions either on the three phases simultaneously or on one or two phases only.

For protective **controls** declared according to requirement 90 of Table 1, the following additional test applies:

*Protective **controls** shall be subjected to voltage dips and interruptions at random phase angles with respect to the mains frequency as well as at the zero crossing of the supply voltage.*

H.26.5.2 Voltage variation test

The purpose of the test is to verify the immunity of the **control** against voltage change taking place over a short period which may occur due to a change of load or stored energy in local power networks.

H.26.5.2.1 Test levels for voltage variations

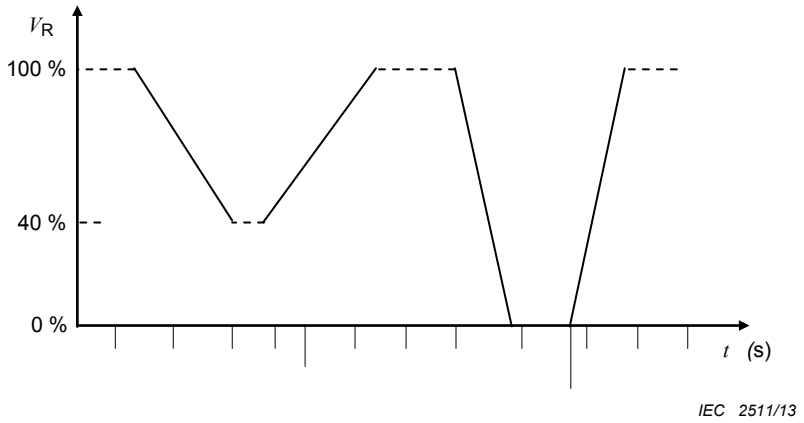
The test values in Table H.15 shall be applied to all the test levels.

H.26.5.2.2 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-11.The duration of the voltage changes and the time for which the reduced voltages are to be maintained are given in Table H.15 and illustrated in Figure H.2. The rate of change of voltage shall be constant; however, the voltage is able to be stepped. The steps shall be positioned at 0 crossing and shall be not larger than 10 % of V_R. Steps under 1 % of V_R are evaluated as constant rate of change of voltage.

Table H.15 (H.26.5.4.2 of edition 3) – Test values for voltage variations

Voltage test level	Time for decreasing voltage	Time at reduced voltage	Time for increasing voltage
40 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
0 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
	x	*x*	*x*
NOTE *x* represents an open set of durations and is able to be specified in part 2.			



NOTE The voltage gradually decreases.

Figure H.2 – Voltage variation test

The **control** is subjected to each of the specified voltage test cycles three times with 10 s intervals between each test cycle for the most representative modes of **operation**. Additional voltage test levels may be specified in part 2.

H.26.6 Test of influence of voltage unbalance

H.26.6.1 Purpose of the test – Range of application

This test applies only to three-phase equipment.

The purpose of the test is to investigate the influence of unbalance in a three-phase voltage system on equipment sensitive to this kind of interference, such as:

– *overheating of a.c. rotating machines;*
– *generation of non-characteristic harmonics in electronic power converters.*

The degree of unbalance is defined by the unbalance factor $T_i = \frac{U_i}{U_d} = \frac{\text{negative sequence voltage}}{\text{positive sequence voltage}}$

H.26.6.2 Test voltage characteristics

*A power frequency three-phase voltage shall be applied to the **control** with the specified unbalance factor.*

NOTE In order to obtain accurate results, a voltage with very small harmonics content can be used.

H.26.6.3 Test equipment/test generator

The test arrangement shall consist of three single-phase auto-transformers, whose outputs are regulated individually, or the like.

H.26.6.4 Test level

The test shall be carried out with an unbalance factor of 2 %.

H.26.7 [C] Void [C]

H.26.8 Surge immunity test

The **control** shall tolerate voltage surges on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.26.8.2 to H.26.8.3 inclusive.

H.26.8.1 Purpose of the test

*This test applies to the power supply terminals and in specific cases to the **control** terminals (see H.26.8.2).*

***Controls** providing **electronic disconnection** are loaded as indicated in 17.2 and subjected to the test levels for the installation class specified for the **control** by the manufacturer, when the **control** is providing **electronic disconnection**. During and after the test, the **control** shall continue to provide **electronic disconnection**, as determined by the test of H.11.4.16.2. If, during the test, the **electronic disconnection** is caused to be conductive for one-half cycle of the supply frequency after application of one surge, this is not considered to be a **fault**.*

The purpose of this test is to verify the immunity of the **control** against unidirectional surges caused by different phenomena:

– switching phenomena in the power network (for example, switching of capacitor banks);
– **faults** in the power network;
– lightning strikes.

The induced voltage surge can have different effects, depending on the relative impedance of the source and of the **control**:

– if the **system** has a high impedance relative to the source, the surge will produce a voltage surge;
– if the **control** has a relative low impedance, the surge will produce a current pulse.

This behaviour can be illustrated by an input circuit protected by an overvoltage suppressor: as soon as the latter breaks down, the input impedance becomes very low. A realistic test shall correspond to this behaviour and the test generator shall be able to deliver a voltage pulse on a high impedance as well as a current pulse on a low impedance (hybrid generator).

H.26.8.2 Test values

The tests as detailed in Table H.16 shall be applied.

*The tests on the terminals for signal, data, **control** and other input lines shall only be performed if these terminals are designed to make an interconnection with cables longer than 10 m, according to the manufacturer's specifications.*

*For **protective controls** declared according to requirement 90 of Table 1, the following additional test applies:*

[A1] *The power supply terminals of the **control** are subjected to an open circuit test voltage of 4 kV (applicable for the line-to-earth coupling mode) with a generator having a source* [A1]

impedance of 12 Ω being used, and to an open circuit test voltage of 2 kV (applicable for the line-to-line coupling mode) with a generator having a source impedance of 2 Ω being used.

Table H.16 (H.26.8.2 of edition 3) – Test voltages for test level 2 (depending on the installation class conditions)

Test values peak kV						
IEC 61000-4-5 installation class	**Power supply**		**Unbalanced operated circuits and lines**		**Balanced operated circuits and lines**	
	Coupling mode		**Coupling mode**		**Coupling mode**	
	Line to line	**Line to earth**	**Line to line**	**Line to earth**	**Line to line**	**Line to earth**
2	0,5	1,0	0,5	1,0	No Test	1,0
3	1,0	2,0	1,0	2,0	No Test	2,0
4	2,0	4,0	2,0	4,0	No Test	2,0

NOTE 1 For test level 3 requirements, apply the next higher installation class. For test level 4 requirements, apply installation class 4 values.

NOTE 2 Tests are performed with any intended surge suppression properly installed.

NOTE 3 In a **control**, a lower category may follow any higher category when appropriate **transient overvoltage** control means are provided.

NOTE 4 See Annex R for description of installation class and further explanatory notes.

At test level 2) and 3), after the tests of H.26.8.2, the surge protective components shall not be destroyed.

H.26.8.3 Test procedure

The test apparatus and procedure shall be as described in IEC 61000-4-5. In accordance with this standard, the **control** is connected to an appropriate source of supply operating at the rated voltage with the impulse generator connected across the terminals.

The tests are carried out by subjecting the **system** to five pulses of each polarity, positive and negative (+, –) and with phase relationships of at least 0°, 90°, 180° and 270° distributed over the relevant operating modes and with the voltage values listed in Table H.16 at intervals not greater than 60 s or as specified in the relevant part 2.

If varistors are used as surge protective devices, they shall comply with IEC 61643-11. Additionally, they shall be selected to withstand the impulses corresponding to the installation class for which the **control** is intended to be used.

For **controls** having surge protective device arresters incorporating spark gaps, the test is repeated at a test level that is 95 % of the flashover voltage.

The **control** is tested and assessed in each of the relevant operating modes, as specified in the relevant part 2.

H.26.9 Electrical fast transient/burst immunity test

*The **control** shall tolerate fast transient bursts on the mains supply and on the signal lines.*

Compliance is checked by the test of H.26.9.2 to H.26.9.3 inclusive.

H.26.9.1 Purpose of the test

*This test applies to the power supply terminals and in specific cases to the **control** terminals (see H.26.9.2).*

*The purpose of this test is to demonstrate the immunity of the **control** to bursts of fast low energy transients which may be produced by relays, contactors, etc., switch inductive loads and which may be induced into signal and data circuits.*

H.26.9.2 Test levels

The tests shall be applied as specified in Table H.17.

The tests on the terminals for interface cables shall only be performed if these terminals are designed to make an interconnection with cables longer than 3 m, according to the manufacturer's specifications.

Generator drive: *internal*

Duration: *1 min each positive (+) and also negative (–) polarity*

Operating conditions: *as in the relevant part 2*

The test voltage on power supply port shall be applied simultaneously between the ground reference plane and all of the power supply terminals (common mode).

Table H.17 – Test level for electrical fast transient burst test

		Open circuit output test voltage and repetition rate of the impulses			
		On power port, PE		On I/O (Input/Output) signal, data and control ports	
Applicable test levels corresponding to H.26.15.3	Test level in accordance with IEC 61000-4-4	Voltage peak kV	Repetition rate kHz	Voltage peak kV	Repetition rate kHz
2	2	1	5	0,5	5
3	3	2	5	1	5
Protective controls declared in Table 1, requirement 90 intended for use in accordance with IEC 60335-1	4	4	5	-	-

H.26.9.3 Test procedure

The test apparatus and test procedures shall be as described in IEC 61000-4-4.

The **control** is tested in each of the relevant operating modes, as specified in the relevant part 2.

H.26.10 〖C〉 Void 〈C〗

H.26.11 Electrostatic discharge test

This test is carried out in accordance with IEC 61000-4-2.

The test values shall be applied to test level 3.

*Direct application of discharge: Contact discharges at 6 kV to accessible metal parts, or air discharges at 8 kV to **accessible parts** of insulating material shall apply.*

Indirect application of discharge: Contact discharges at 6 kV to horizontal or vertical couple plate shall apply.

For **protective controls** declared according to requirement 90 of Table 1, the following additional test applies: This test is carried out in accordance with Clause 5, test level 4 of IEC 61000-4-2:2008. Contact discharges at 8 kV to accessible metal parts, or air discharges at 15 kV to **accessible parts** of insulating material shall apply.

H.26.12 Radio-frequency electromagnetic field immunity

H.26.12.1 Purpose of the test

The purpose of the test is to verify the immunity of **controls** against electromagnetic fields generated by radio transmitters or any other device emitting continuous wave radiated electromagnetic energy. The immunity of **controls** to the radiation of hand-held transceivers (walkie-talkies) is the main concern but other sources of electromagnetic radiation are involved, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electro-magnetic sources of intermittent sources.

H.26.12.1.1 If the criticality of test level 2 testing is not affected after test level 3 testing, the testing of test level 2 need not be carried out.

H.26.12.2 Immunity to conducted disturbances

*The **control** shall tolerate high frequency signals on the mains supply and relevant signal terminals.*

Compliance is checked with the tests of H.26.12.2.1 to H.26.12.2.2, inclusive.

H.26.12.2.1 Test levels for conducted disturbances

At minimum, the test levels in Table H.19 shall be applied.

The tests shall only be applied to interface cables which, according to the manufacturer's specification, may be longer than 1 m.

Table H.19 (H.26.12.2.1 of edition 3) – Test levels for conducted disturbances on mains and I/O lines

Test frequency range: 150 kHz to 80 MHz		
Test level	Voltage level (r.m.s.)	
	U_0 dBμV	U_0 V
2	130	3
3	140	10
NOTE The test levels in the ISM- and CB-bands are chosen to be 6 dB higher. (ISM: Industrial, scientific and medical radio-frequency equipment: 13,56 MHz ± 0,007 MHz and 40,68 MHz ± 0,02 MHz, CB: Citizen band: 27, 125 MHz ± 1,5 MHz).		

H.26.12.2.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-6.

*Test the **control** by sweeping through the complete test frequency range at least once with the **system** in each of its relevant operating modes. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value with linear interpolation between calibration points. The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the **control** to be exercised and be able to respond, but in no case be less than 0,5 s.The ISM and CB bands shall be tested with those test frequencies that have been used by sweeping through the complete test frequency range and cover the ISM and CB bands regarded.*

NOTE The sensitive frequencies or the frequencies of dominant interest can be analyzed separately.

H.26.12.3 Immunity to radiated disturbances

The **control** shall tolerate high-frequency signals on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.26.12.3.1 to H.26.12.3.2 inclusive.

H.26.12.3.1 Test level for radiated electromagnetic fields

Test levels for immunity to radiated electromagnetic fields shall be applied in accordance with Table H.20.

Increased test levels for radiated immunity shall be applied in accordance with Table H.21.

Table H.20 (H.26.12.3.1 of edition 3) – Test level for immunity to radiated electromagnetic fields

	Test frequency ranges/Field strength V/m		
Test level	**80 MHz to 960 MHz**	**1,4 GHz to 2,0 GHz**	**2,0 GHz to 2,7 GHz**
2	3	3	1
3	10	3	1

Table H.21 – Increased test level for radiated immunity (ISM, GSM, DECT bands)

	Test frequency ranges/Field strength V/m					
Test level	**433 MHz to 435 MHz**	**864 MHz to 915 MHz**	**935 MHz to 960 MHz**	**1 710 MHz to 1 784 MHz**	**1 805 MHz to 1 960 MHz**	**2 446 MHz to 2 454 MHz**
2	6	6	6	6	6	2
3	20	20	10	6	6	2

H.26.12.3.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-3.

*Test the **control** by sweeping through the complete test frequency ranges in both the horizontal and the vertical antenna orientation in each of its relevant operating modes. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value with linear interpolation between calibration points. The dwell time at each frequency shall not be less than the time necessary for the **control** to be exercised and to respond, but shall in no case be less than 0,5 s. The ISM, GSM and DECT bands shall be tested with those test frequencies that have been used when sweeping through the complete test frequency ranges and cover completely the ISM, GSM and DECT bands regarded.*

*The test shall normally be performed with the generating antenna facing each side of the **control**. When equipment can be used in different orientations (i.e. vertical or horizontal) all sides shall be exposed to the field during the test. When technically justified, some **controls** can be tested by exposing fewer faces to the generating antenna. In other cases, as determined for example, by the type and size of **control** or the frequencies of test, more than four azimuths may need to be exposed.*

NOTE The sensitive frequencies or the frequencies of dominant interest can be analyzed separately.

H.26.13 Test of influence of supply frequency variations

*Micro-processor based **controls** declared as **class B control function** and/or **class C control function** which rely on the mains supply frequency for the correct **operation** shall tolerate frequency variations of the mains supply frequency, if declared by the manufacturer in the additional items to Table 1 of Clause H.7.*

H.26.13.1 Purpose of the test

The purpose of this test is to verify the effect on the **control** from frequency deviation on the mains.

H.26.13.2 Test levels

The test values in Table H.22 shall be applied.

Table H.22 (H.26.13.2 of edition 3) – Test level for supply frequency variations

Test level	**Variations in supply frequency %** [a]
2	±1 and ±2
3	±3, ±4 and ±5

[a] Other values may be specified in part 2.

H.26.13.3 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-28.

The **control** shall be initially operated at its rated voltage and shall then be subjected to the frequency variations as detailed in H.26.13.2.

H.26.14 Power frequency magnetic field immunity test

The **controls** which are susceptible to magnetic field such as **controls** which use Hall-effect devices shall tolerate power-frequency magnetic fields.

Compliance is checked by the tests of H.26.14.2.

NOTE Examples of such **controls** include pressure sensors which use Hall-effect devices, **controls** incorporating reed relays and **controls** utilizing bistable relays.

H.26.14.1 Purpose of the test

The purpose of the test is to demonstrate the immunity of **controls** which may be affected by power-frequency magnetic fields related to the specific location and installation conditions of the **control** (for example, proximity of the equipment to the disturbance source).

The power-frequency magnetic field is generated by power-frequency currents in conductors or from other devices (for example, leakage of transformers) in the proximity of equipment.

Only the influences of nearby conductors should be considered, where the current under normal operating conditions, produces a steady (continuous) magnetic field, with a comparatively small magnitude.

H.26.14.2 Test levels

The test levels shall be applied in accordance with Table H.23.

Table H.23 (H.26.14.2 of edition 3) – Test level for continuous fields

Test level	Continuous field strength A/m
2	3
3	10

H.26.14.3 Test procedure

The **control** is supplied at rated voltage. Test equipment, test set-up and test procedure shall be in accordance with IEC 61000-4-8. The **control** is tested under the test conditions as specified in the relevant part 2.

H.26.15 Evaluation of compliance

H.26.15.1 After the tests of H26.2 through H.26.14 and H26.16, the sample(s) shall meet the requirements of Clause 8, 17.5 and Clause 20.

H.26.15.2 In addition, the **control** shall meet the following:

– the requirements of H.17.14 or

– the output(s) and functions shall be as declared in Table 1, requirements 58a and 58b.

*Compliance with the second alternative of H.26.15.2 may make the **control** unacceptable for some applications.*

Parts 2 may contain restrictions on the allowable effects on controlled output(s) for particular types of **controls** or **control** functions for test levels.

H.26.15.3 Different outputs and functions may be declared by the manufacturer after testing at test level 2, or test level 3, if relevant. Part 2 may specify particular criteria after each of these tests.

H.26.15.4 The compliance criteria shall be given in part 2 and shall be based on the operating output conditions and the functional specifications of the **control** under test:

a) normal performance with no loss of protective functions and **control** is within specification or declared limits;

b) loss of protective function within declared limits;

c) loss of protective function with **safety shut-down**;

d) loss of protective function with unsafe **operation**.

H.27 Abnormal operation

H.27.1 Electronic controls – Assessment against internal faults

H.27.1.1 Electronic controls shall be assessed for the effects of **failure** or malfunction of circuit components to ensure electrical safety.

Compliance is checked by the tests of H.27.1.1.1 to H.27.1.1.6 inclusive and H.27.4.

Components which fail as a result of cumulative stress are replaced if necessary.

NOTE Non-electronic components such as switches, relays and transformers, which are assessed according to Clause 24 or to the relevant requirements of this standard, are not subjected to the tests of H.27.1.1.

During the tests of H.27.1.1, for a **control** providing **electronic disconnection** (type 1.Y or 2.Y), any **failure** of the device described in footnote n to Table 12 is permitted.

H.27.1.1.1 Fault conditions specified in ⟦AC1⟩Table H.24⟨AC1⟧ are not applied to circuits or parts of circuits where all of the following conditions are met:

– the electronic circuit is a low-power circuit as described below;

– the protection against electric shock, fire **hazard**, mechanical **hazard** or dangerous malfunction in other parts of the **control** does not rely on the correct functioning of the electronic circuit.

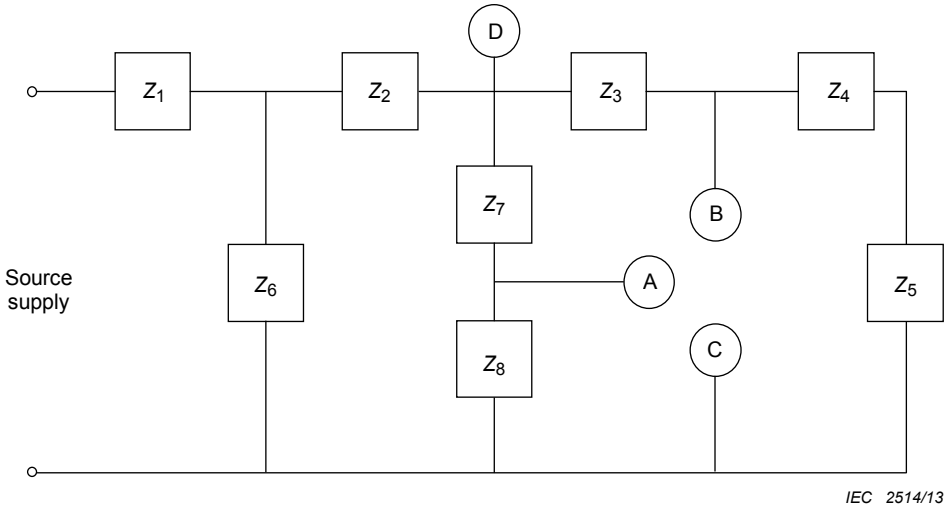
*A low-power circuit is determined as follows and further explained in Figure H.5. The **control** is operated at rated voltage or at the upper limit of the rated voltage range and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite pole of the supply source.*

The resistance is then decreased until the power consumed by the resistor reaches a maximum. Any point nearest to the supply and at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s is called a low-power point. The part of the circuit farther from the supply source than a low-power point is considered to be a low-power circuit.

The measurements are made from only one pole of the supply source, preferably the one that gives the fewest low-power points.

NOTE When determining the low-power points, start with points close to the supply source. The power consumed by the variable resistor is measured by a convenient method, for example, by a wattmeter.

*If an electronic circuit operates to ensure compliance with Clause H.27, the relevant test is repeated with a single **fault** simulated, as indicated in H.27.1.1.5.*



D is a point farthest from the supply source where the maximum power delivered to external load exceeds 15 W.

A and B are points closest to the supply source where the maximum power delivered to external load does not exceed 15 W. These are low-power points.

Points A and B are separately short-circuited to C.

The **fault** conditions specified in H.27.1.1.5 are applied individually to Z_1, Z_2, Z_3, Z_6 and Z_7, where applicable.

Figure H.5 – Example of an electronic circuit with low power points

H.27.1.1.2 *The **control** shall be operated under the following conditions.*

a) At the most unfavourable voltage in the range 0,9 to 1,1 times the rated supply voltage.

b) Loaded with the type of load, within the declared or measured parameters, producing the most onerous effect.

c) In an ambient temperature of (20 ± 5) °C, unless there are significant reasons (as for example during item b) of H.27.1.1.3) for conducting the test at another temperature within the manufacturer's declared range.

*d) Connected to an electrical supply having a fuse rating such that the result of the test is not influenced by the **operation** of the fuse.*

*e) With any **actuating member** set to the most unfavourable position.*

H.27.1.1.3 With each **fault** described in Table H.24, simulated or applied to one circuit component at a time, the **control** shall comply with

– the following items a) to g) inclusive. For components complying with Clause 14 of IEC 60065:2001, Amendment 1: 2005, Amendment 2:2010, the **controls** need only comply with items a), c), d), f) and g).

〖C〗 *Text deleted* 〈C〉

– any additional compliance criteria, as specified in the applicable subclauses of part 2; and
– the requirements of specified software class, if declared.

a) The **controls** shall not emit flames, hot metal or hot plastics, and no explosion shall result. For **in-line cord controls** and **independently mounted controls**, compliance is determined by the following test.

The enclosure with the **control** therein is wrapped in tissue wrapping paper. The **control** is operated to steady state or for 1 h, whichever occurs first. There shall be no burning of the wrapped tissue paper. Inside the enclosure, some parts may temporarily glow, and there may be a temporary emission of smoke or flame.

NOTE 2 [C]The wrapping tissue paper is specified in ISO 4046:1978 as thin, soft, relatively tough paper, generally intended for packing delicate articles, its substance being between 12 g/m^2 and 25 g/m^2.[C]

Integrated and **incorporated controls** shall either comply with the test specified for **in-line cord controls** and **independently mounted controls** or be classified as requiring, for example, further shielding, in the appliance or equipment.

b) The temperature for **supplementary insulation** and **reinforced insulation** shall not exceed 1,5 times the relevant values specified in Clause 14, except in the case of thermoplastic material.

There is no specific temperature limit for **supplementary insulation** and **reinforced insulation** of thermoplastic material, the temperature of which shall, however, be recorded for the purpose of Clause 21.

c) Any change in the controlled outputs shall be as declared in Table 1, requirement 57.

d) The **control** shall comply with the requirements of Clause 8 and 13.2 for **basic insulation**.

e) There shall be no deterioration of the various parts of the **control** that would result in non-compliance with the requirements of Clause 20.

f) A fuse in the supply, external to the **control** under test and as described in item d) of H.27.1.1.2 shall not blow unless an internal protective device also operates that is accessible only after the use of a **tool**.

An internal protective device is deemed not to be required if the sample still complies with the following requirements after replacement of the fuse of the supply:

– items a), b) and d) of H.27.1.1.3;

– the requirements of Clause 20 for the **clearances** and **creepage distances** from **live parts** to the surfaces of the **control** that are accessible when the **control** is mounted as for its intended use.

g) The output waveform shall be as declared in Table 1, requirement 56.

H.27.1.1.4 Guidelines for the tests of H.27.1.1.3

*To avoid unnecessary testing, every endeavour should be made to assess all the conditions likely to result in non-compliance with the requirements of H.27.1.1.4. Such an assessment shall involve an appraisal of the circuit diagram and simulation of the relevant **fault** conditions so as to test whether these conditions occur. For **controls** using software, the **fault** analysis of H.27.1.1.4 shall be related to the software **fault** analysis of Table 1, requirement 68.*

*All conditions which result from the introduction of an electronic circuit **fault** as specified in H.27.1.1.5 are considered to be one **fault**.*

Printed circuit conductors which show signs of deterioration during the tests are considered liable to fail.

H.27.1.1.5 Electronic circuit fault conditions

For the purpose of Clause H.27, the applicable **failure** modes are given in Table H.24.

Table H.24 (H.27.1 of edition 3) – Electrical/electronic component fault modes table
(1 of 3)

Component type	Short [a]	Open [b]	Remarks
Fixed resistors			
Thin-film [c]		X	Includes SMD type
Thick-film [c]		X	Includes SMD type
Wire-wound [c] (single layer) enamelled or suitably coated		X	
All other types	X	X	
Variable resistors			
(for example, potentiometer/trimmer)			
Wire-wound (single layer)		X	
All other types	X [d]	X	
Capacitors			
X1 and Y types according to IEC 60384-14		X	
Metallized film according to IEC 60384-16 and IEC 60384-17		X	
All other types	X	X	
Inductors			
Wire-wound		X	
All other types	X	X	
Diodes			
All types	X	X	
Semiconductor type devices like transistors			
All types (for example, bipolar; LF; RF; microwave; FET; thyristor; Diac; Triac; Uni junction)	X [d]	X	[e]
Hybrid circuit	[f]	[f]	
Integrated circuits			
All types not covered by H.11.12	X [g]	X	For IC outputs, footnote e applies
Optocouplers			
According to IEC 60335-1	X [h]	X	
Relays			
Coils		X	
Contacts	X [i]	X	
Reed-relays	X	X	Contacts only
Transformers			
According to IEC 61558-2-6 or IEC 61558-2-16		X	
All other types	X [d]	X	
Crystals	X	X	[j]
Switches	X	X	[k]
Connections (jumper wire)		X	[l]
Cable and wiring		X	

Table H.24 *(2 of 3)*

Component type	Short [a]	Open [b]	Remarks
Printed circuit board conductors According to IEC 62326 series	X [m]	X [n]	
Sensors			
Polymeric type **thermistors**	X	X	[o]
Ceramic type **thermistors**		X	

[a] The conditions which have led to the design of the **clearances** and **creepage distances** according to Clause 20 on the assembly for which exclusion from the **fault** mode “short” is claimed shall be maintained over the lifetime of the **control**.

These conditions shall be declared or documented as follows.

Control pollution situation (Table 1, requirement 49).

Pollution situation in the **micro-environment** of the **creepage distance** or **clearance**, if cleaner than that of the **control**, and how this is designed (documentation) (Table 1, requirement 79).

Rated impulse voltage of the **control** (Table 1, requirement 75).

Rated impulse voltage for the **creepage distance** or **clearance**, if different from that of the **control**, and how this is ensured (documentation) (Table 1, requirement 80).

The values designed for tolerances of distances for which the exclusion from **fault** mode "short" is claimed. (declaration and documentation) (Table 1, requirement 81).

[b] Only opening of one pin at any one time.

[c] These components may be used for **protective impedance**, if the impedance of components complies with H.20.1.15.3 and withstands the impulse voltage test of 20.1.12 for at least **overvoltage category** III.

[d] Short-circuit each pin in turn with every other pin; only two pins at a time.

[e] For discrete or integrated thyristor type devices such as Triacs and SCRs, fault conditions shall include short circuit of any terminals with the third terminal open-circuited. The effect of any full wave type of component, such as a Triac going into a half-wave condition, either controlled or uncontrolled (thyristor or diode, respectively) shall be considered.

Failure of a field effect based electronic power switching device (FET, MOSFET, IGBT) by loss of gate (base) control* resulting in a partial turn-on mode, causing an undefined state shall be considered. Testing and assessment criteria shall correspond to the specific **control** function and circuitry. Guidance might be given in parts 2.

*Loss of gate control might occur due to, for example, an insufficient solder connection of the FET.

[f] **Failure** modes for individual components of the **hybrid circuit** are applicable as described for the individual components in this table.

[g] The short circuit of any two adjacent terminals and the short circuiting of

- each terminal to the IC-supply, when applicable at the IC;
- each terminal to the IC-ground, when applicable at the IC.

The number of tests implied for **integrated circuits** may normally make it impracticable to apply all the relevant **fault** conditions or to assess the likely **hazards** from an appraisal of the circuit diagram of the **integrated circuit**.

It is therefore permissible first to analyse in detail all the possible mechanical, thermal and electrical **faults** which may develop either in the **control** itself or its output, due to the malfunction of the **electronic devices** or other circuit components, separately or in any combination.

Except for types evaluated by H.11.12, a **fault**-tree analysis shall be conducted to include the results of multiple steady-state conditions to outputs and programmed bi-directional terminals for the purpose of identifying additional **fault** conditions for consideration. The **failure** mode "short circuit" is excluded between isolated sections for such ICs that have isolated sections. The isolation between the sections shall comply with the requirements of 13.2 for **functional insulation**.

[h] When optocouplers comply with A1 20.3.2.2, A1 the shorting between the input and output pins is not considered.

Table H.24 *(3 of 3)*

[l] The short-circuit mode is excluded for relays where the contact is controlling a Class A or B **control** function, and is not included in the specified cyclic operation of the application, provided that it is successfully tested to Clause 17 under the following conditions:

For Class A **control** functions, the number of cycles declared by the manufacturer, or certified for the application.

For Class B **control** functions, a minimum of 100 000 cycles or otherwise specified by the manufacturer, whichever is higher, or certified for the application.

For Class C **control** functions, the short-circuit mode is excluded for relays where

- the contact function is switching under normal **operation** without load (no current flowing during make or break) and
- the contact function is disconnecting the load under abnormal **operation** of the burner **control system** to reach **safety shut-down** and
- the relay complies with Clause 17 at a minimum of 100 000 cycles however applying the declared output load, or certified for the application, and
- the **control** complies with the requirements of 11.3.5.2.1 (measures to prevent **common cause errors**).

[j] For crystal-based clocks, harmonic and sub-harmonic frequency variations affecting the timings should be considered.

[k] If switches are applied for the selection of safety times, purge times, programmes and/or other safety-related **settings,** these devices should function so that in the event of their opening, the safest possible condition arises (for example, in a burner **control system**, the shortest safety time or the longest purge time).

The short-circuit mode is excluded for switches where the contact is controlling a Class A or B **control** function, provided that it is successfully tested to Clause 17 under the following conditions:

For Class A **control** functions, the number of cycles declared by the manufacturer, or certified for the application.

For Class B **control** functions, a minimum of 6 000 cycles for **manual action**, or 100 000 cycles for automatic action, or otherwise specified by the end product standard, or certified for the application.

For Class C control functions, short-circuit mode is not excluded.

[l] The requirements are the same as footnote n, except they are applied to jumper wires intended for clipping when selecting a **setting**.

[m] The short-circuit **failure** mode is excluded if the requirements of Clause 20 are fulfilled.

[n] The open-circuit **failure** mode, i.e. interruption of a conductor, is excluded if

- the thickness of the conductor is equal to, or greater than, a nominal value of 35 μm with a tolerance up to –30 % of the nominal value allowed, and the breadth of the conductor is equal to, or greater than, a nominal value of 0,3 mm with a tolerance up to –30 % of the nominal value allowed, or
- the conductor has an additional precaution against interruption, for example, roll-tinned, etc.

If a short circuit at the output terminals causes the opening of a printed circuit board conductor, that conductor shall be subject to an open-circuit **fault** analysis.

For temperature and current conditions when accepting conductor sizes, see IEC 62326 series.

[o] For sensor components intended to measure activating quantities such as temperature, pressure etc., **fault** modes in addition to open and short must be considered. These **fault** modes can include step wise shift of resistance, non-responsive component, and component drifting out of accuracy.

H.27.1.1.6 *If the load includes a motor load (see 6.2.2 or 6.2.5), and the **failure** or malfunction of an electronic circuit component causes a change in the supply waveform to the controlled motor, the **control** shall be subjected to the following tests.*

1) The load shall be adjusted under normal waveform conditions to six times the rated load or the locked rotor rating declared by the manufacturer.

*2) Then the **fault** conditions shall be introduced.*

3) The test is conducted under the conditions described in items a), c), d) and e) of H.27.1.1.2.

The control shall be evaluated according to items a) to e) inclusive of H.27.1.1.3, as appropriate to the component being assessed.

H.27.1.2 Protection against internal faults to ensure functional safety

H.27.1.2.1 Design and construction requirements

H.27.1.2.1.1 Fault avoidance and fault tolerance

In addition to H.27.1.1, **controls** incorporating **control** functions of class B or C shall be designed according to H.27.1.2 taking into account the **failure** modes of Table H.24 and H.11.12 for software, if applicable.

Failures of **complex electronics** can be caused by either systematic errors (built into the design, see H.11.12.3) or by random **faults** (component **faults**, see H.11.12.2). Therefore, the **system** shall be designed in such a way that systematic errors are avoided and random **faults** shall be dealt with by a proper **system** configuration.

The design of the software and hardware shall be based on the functional analysis of the application-resulting in a structured design explicitly incorporating the **control** flow, data flow and time related functions required by the application. In the case of custom-chips special attention is required with regard to measures taken to minimize systematic errors.

This shall result in a **system** configuration which is either inherently failsafe or in which components with direct safety-critical functions (e. g. gas valve drivers, microprocessors with their associated circuits, etc.) are guarded by safeguards in accordance to H.11.12 software class B or C. These safeguards shall be built into hardware (e. g. watch-dog, supply voltage supervision) and can be supplemented by software (e. g. ROM-test, RAM-test, etc.). It is important that these safeguards can cause a completely **independent safety shut-down**.

If time slot monitoring is used, it shall be sensitive to both an upper and a lower limit of the time interval. **Faults** resulting in shift of the upper and/or lower limit shall be taken into account.

In case of a **control** function that is classified as class C, if a single **fault** in a primary safeguard can render the safeguard inoperative, a secondary safeguard shall be provided. The reaction time of the secondary safeguard shall be in accordance with H.27.1.2.3.

NOTE 1 Reaction times of these safeguards can be equal or smaller than the relevant **fault tolerating time**.

NOTE 2 The secondary guarding can be realized by:

a) a physically separate circuit monitoring the primary safeguard; or

b) mutual action between the circuit being safeguarded and the primary safeguard (e. g. a watch-dog guarded by the microprocessor); or

c) action between primary safeguards (e. g. a ROM-test guarding a RAM-test).

Components shall be dimensioned on the basis of the worst-case conditions which can arise in the **control**, as stated by the manufacturer.

NOTE 3 A component **failure** could cause a **degradation** of safety critical insulation.

H.27.1.2.1.2 Documentation

In general the documentation shall be based on H.11.12.3.2.

The functional analysis of the **control** and the safety related programs under its control shall be documented in a clear hierarchical way in accordance with the safety philosophy and the programme requirements.

As a minimum the following documentation shall be provided with any **system** submitted for assessment:

a) A description of the **system** philosophy, the **control** flow, data flow and timings.

b) A clear description of the safety philosophy of the **system** with all safeguards and safety functions clearly indicated. Sufficient design information shall be provided to enable the safety functions or safeguards to be assessed.

c) Documentation for any software within the **system**.

Programming documentation shall be supplied in a programming design language declared by the manufacturer.

Safety related data and safety related segments of the **operating sequence** shall be identified and classified according to H.11.12.3.2.

There shall be a clear relationship between the various parts of the documentation, for example, the interconnections of process, hardware and the labeling used in software documentation.

If a manufacturer provides documentation of the analytical measures taken during the development stage of the hardware and software, this documentation shall be used by the test house as part of the assessment procedure.

H.27.1.2.2 Class B control function

H.27.1.2.2.1 Design and construction requirements

A **class B control function** shall be designed such that under single **fault** conditions it remains in or proceeds to the **defined state**. A second **independent fault** is not considered.

NOTE **Failure** of **class B control function** in the presence of another **fault** in the appliance, or **failure** of **class C control function** alone, could result in a dangerous malfunction, electric shock, fire, mechanical or other **hazards**.

Software shall comply with software class B.

The class of **control** function shall be identified in Table 1, requirement 92.

The assessment shall be performed according to H.27.1.2.2.2 and H.27.1.2.2.3 and under the test conditions and criteria of H.27.1.2.5.

H.27.1.2.2.2 First fault

Any first **fault** (see Table H.24) in any one component or any one **fault** together with any other **fault** arising from that first **fault** shall result in either:

a) the **control** becoming inoperative with all safety related output terminals de-energized or assuming a status in which they ensure a safe situation;

b) the **control** reacting within the **fault reaction time** (see Table 1, requirement 91) by proceeding to a **defined state**, provided that subsequent **reset** from the **defined state** under the same **fault** condition results in the **system** returning to the same **defined state**;

c) the **control** continuing to operate, the **fault** being identified during the next start-up sequence, the result being a) or b);

d) the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2.

The relevant part 2 shall specify the **fault reaction time** as well as the applicability of c).

For **defined state** with a mechanical actuator, a test up to but not including the switching contacts is sufficient. If the test of the **defined state** fails, the **system** shall proceed to **safety shut-down**. Frequency of test is given in the relevant part 2. Internal **faults** on components of the checking circuit are not considered.

H.27.1.2.2.3 Fault introduced during defined state

Whenever the **control** is in a **defined state** without an internal **fault**, the following requirements apply.

Any first **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table H.24), induced while the **control** is staying in a **defined state**, shall result in either:

a) The **control** remaining in a **defined state**, safety related output terminals remaining de-energized; or

b) the **control** becoming inoperative with all safety related output terminals remaining de-energized; or

c) the **control** comes again in **operation** resulting in a) or b) as mentioned in this clause under the condition that the safety related output terminals are energized not longer than the **fault reaction time** (see Table 1, requirement 91). If the cause of the **defined state** condition no longer remains and the **control** comes again in **operation**, it shall operate in accordance with the safety related functional requirements of the relevant part 2.

H.27.1.2.3 Class C control function

H.27.1.2.3.1 Design and construction requirements

A **class C control function** shall be designed such that under first and second **fault** conditions it remains in or proceeds to the **defined state**. A third **independent fault** is not considered.

NOTE **Failure** of **class B control function** in the presence of another **fault** in the appliance, or **failure** of **class C control function** alone, could result in a dangerous malfunction, electric shock, fire, mechanical or other **hazards**.

Software shall comply with software class C.

The class of **control** function shall be identified in Table 1, requirement 92.

The assessment shall be performed according to H.27.1.2.3.2, H.27.1.2.3.3 and H.27.1.2.4 and under the test conditions and criteria of H.27.1.2.5.

H.27.1.2.3.2 First fault

Any first **fault** (see Table H.24) in any one component or any one **fault** together with any other **fault** arising from that first **fault** shall result in either:

a) the **control** becoming inoperative with all safety related output terminals de-energized or assuming a status in which they ensure a safe situation;

b) the **control** reacting within the **fault reaction time** (see Table 1, requirement 91) by proceeding to a **defined state**, provided that subsequent **reset** from the **defined state** condition under the same **fault** condition results in the **system** returning to the **defined state**;

c) the **control** continuing to operate, the **fault** being identified during the next start-up sequence, the result being a) or b);

d) the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2.

The relevant part 2 shall specify the **fault reaction time** as well as the applicability of c).

H.27.1.2.3.3 Second fault

If the assessment of the first **fault** results in the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2 (see H.27.1.2.3.2 d)), any further **independent fault** considered together with the first **fault** shall result in either H.27.1.2.3.2 a), b), c) or d).

During assessment, the second **fault** shall only be considered to occur:

a) either when a start-up sequence has been performed between the first and the second **fault**, or

b) 24 h after the first **fault**.

The relevant part 2 shall specify the applicability of a) or b) and the **fault reaction time** (see Table 1, requirement 91).

It may also specify a different time span in which the second **fault** does not occur, if different from 24 h.

H.27.1.2.4 Faults during defined state

H.27.1.2.4.1 General

Whenever the **control** is in a **defined state** without an internal **fault**, an assessment according to H.27.1.2.4.2 and H.27.1.2.4.3 shall be performed.

Whenever the **control** is inoperative with all safety related output terminals de-energized or in a status in which they ensure a safe situation, in a **defined state** with an internal **fault**, an additional single **fault** assessment according to H.27.1.2.4.3 shall be performed.

NOTE Safety related output terminal as used in H.27.1.2.4.2 and H.27.1.2.4.3 are terminals which are safety related even in the **safety shut-down** or in a **defined state**, for example, gas valve terminal, but not a terminal for an actuator driving the controlling element which does not degrade the safety in the **defined state**.

H.27.1.2.4.2 First fault introduced during defined state

Any first **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table H.24), induced while the **control** is staying in the **safety shut-down** position, shall result in either:

a) the **control** remaining in a **defined state**, safety related output terminals remaining de-energized or in a status in which they ensure a safe situation;

b) the **control** becoming inoperative with all safety related output terminals remaining de-energized or assuming a status in which they ensure a safe situation;

c) the **control** comes again in **operation** resulting in a) or b) as mentioned in H.27.1.2.4.2 under the condition that the safety related output terminals are energized not longer than the **fault reaction time** (see Table 1, requirement 91). If the cause of the original **safety shut-down** condition no longer remains and the **control** comes again in **operation**, it shall operate in accordance with the safety related functional requirements of the relevant part 2 and the second **fault** assessment shall be carried out in accordance with H.27.1.2.3.3.

H.27.1.2.4.3 Second fault introduced during defined state

Any second **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table H.24), induced while the **control** is staying in the **defined state**, shall result in either H.27.1.2.4.2 a), b) or c).

During assessment, the second **fault** shall not be considered to occur within 24 h after the first **fault**.

The relevant part 2 shall specify the **fault reaction time**.

It may also specify a different time span in which the second **fault** does not occur, if different from 24 h.

H.27.1.2.5 Circuit and construction evaluation

H.27.1.2.5.1 Test conditions

The effect of internal **faults** shall be assessed by simulation and/or by an examination of the circuit design.

The **fault** shall be considered to have occurred at any stage in the **control** programme sequence.

The **control** shall be operated or considered to operate under the following conditions:

a) at the most unfavourable voltage in the range 85 % to 110 % of the rated supply voltage;
b) loaded with the most unfavourable load declared by the manufacturer;
c) in an ambient temperature of (20 ± 5) °C, unless there are significant reasons for conducting the test at another temperature within the manufacturer's declared range;
d) with any **actuating member** placed in the most unfavourable position;
e) with tissue paper placed on the supporting surface(s) of the **control**;
f) with sparks of about 3 mm in length and having an energy of not less than 0,5 J applied to those components which are likely to liberate flammable gases during the test.

H.27.1.2.5.2 Test criteria

During the appraisal, it shall be verified that under the conditions described above, the following criteria are satisfied.

a) The **control** shall not emit flames, hot metal or hot plastics, the tissue paper shall not ignite, no explosion shall result from the liberation of flammable gases and any flame produced shall not continue to burn for more than 10 s after switching off the spark generator. When a **control** is incorporated with any appliance, any enclosure afforded by the appliance is taken into consideration.
b) If the **control** continues to function, it shall comply with Clauses 8 and 13 or Clauses 8 and 13 of the relevant part 2. If it ceases to function, it shall still continue to comply with Clause 8 or Clause 8 of the relevant part 2.
c) There shall be no loss of protective function.

After the tests there shall be no deterioration of the various parts of the **control** that would result in failure to comply with Clause 20 or Clause 20 of the relevant part 2.

H.27.1.2.5.3 Assessment

A thorough appraisal of the circuit shall be carried out to determine its performance under the specified **fault** conditions. This appraisal shall take the form of a theoretical analysis and a component **failure** simulation test. **Fault** simulations may also be carried out to simulate **faults** within complex devices, for example, EPROM emulation tests.

Only the safety related software (software class B and C) as identified according to H.27.1.2.1.2 shall be subjected to further assessment. For the identification of the class, a **fault** tree analysis may be used.

H.27.4 Controls providing **electronic disconnection** (type 1.Y or 2.Y) shall withstand the abnormal overvoltage conditions which may occur.

Compliance is checked by the following test:

H.27.4.1 *The **control** is loaded as indicated in 17.2 and subjected to 1,15 × V_R for 5 s, when the **control** is providing **electronic disconnection**.*

H.27.4.2 *During and after the test, the **control** shall continue to provide **electronic disconnection** as determined by the test of H.11.4.16.2.*

H.28 Guidance on the use of electronic disconnection

H.28.1 Main features of solid-state switching devices

H.28.1.1 Solid-state switching devices differ from their electro-mechanical counterparts in three respects:

a) when providing **electronic disconnection**, they will always allow a small current to pass through the circuit which they are controlling;

b) they are more sensitive to mains perturbations of the supply mains;

c) they are more sensitive to temperature.

H.28.1.2 The requirements and tests for **electronic disconnection** in this standard ensure that:

a) the current through the **electronic disconnection** will not exceed 5 mA or 10 % of the rated current, whichever is lower, with any load up to its maximum declared load in the circuit;

b) even under extreme conditions of mains perturbation, a **control** will be unaffected and will not permit the device to conduct for more than one half cycle of the supply waveform;

c) the device will have adequate endurance between the extremes of temperature in which it is designed to operate.

H.28.2 Application of solid-state switching devices

H.28.2.1 An **electronic disconnection** may be caused to conduct for one half cycle of the supply frequency by the application of a pulse of sufficient voltage. While full isolation from the supply is always achieved by the equivalent of **full disconnection**, there may be some applications when **operation** even for one half cycle is unacceptable.

So far as household appliances are concerned, switching on very occasionally for a maximum of one half cycle of the supply waveform can usually be disregarded. It will be of no consequence to heating appliances and to the majority of motor-operated appliances.

However, for motor-operated appliances where it is possible for the **user** to have contact with hazardous moving parts or to parts that become live either during **normal use** or **user maintenance** (for example, cleaning), it will be necessary to require further safeguards or not to allow such devices. Examples of appliances for which **electronic disconnection** would not be appropriate are certain types of kitchen machines where access to moving parts or **live parts** is possible.

WARNING: For some motor-driven appliances, energization of the controlled load at mains frequency for one half cycle may cause rotation of the motor. Operation of solenoid devices may also occur.

H.28.2.2 Where the controlled load is a high impedance load such as a relay coil or solenoid, care shall be taken that the allowed current through the **control** when it is providing **electronic disconnection** is low enough to ensure disconnection of the load.

Annex J
(normative)

Requirements for thermistor elements and controls using thermistors

Annex J supplements or modifies the corresponding clauses of this standard.

J.1 Scope

J.1.1.1 *Additional paragraphs:*

Annex J is applicable to discrete **thermistor**-type devices and to **controls** using **thermistors** constructed of doped ceramic or polymeric semiconductor materials.

Annex J applies to the inherent safety, the operating temperature values and testing of **controls** using **thermistors** either within the **control** or remote from it.

NOTE These **thermistors** can be used:

- in a self-heating mode as **self-controlled heaters** and in similar applications;
- as **control** elements; or
- as **sensing elements**.

Annex J does not apply to **thermistors** used in **control** functions where further measures to ensure safety are implemented within the **control**.

These requirements apply to positive temperature coefficient (PTC) and negative temperature coefficient (NTC) type devices.

Control devices, such as current limiters are not intended to replace current interrupting devices such as fuses, but are intended to provide a level of overcurrent protection complying with the end-use equipment requirements.

Part 2 standards may contain additional requirements for **thermistors** used as complete controls.

J.2 Terms and definitions

J.2.15 Definitions pertaining to thermistors

J.2.15.1
thermistor
thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature (R/T) characteristic a significant non-linear change in its electrical resistance with a change in temperature

Note 1 to entry: The change in temperature can occur either due to flow of current through the **thermistor**, as a result of a change in the ambient temperature, or by a combination of both of these occurrences.

Note 2 to entry: **Thermistors** are not considered to be **electronic devices** (see Annex H).

J.2.15.2
PTC thermistor
positive temperature coefficient (**PTC**) **thermistor** that exhibits an increase in resistance with increasing temperature over the useful portion of the resistance/temperature (R/T) characteristic

Note 1 to entry: **PTC thermistors** also exhibit a decreasing resistance with applied voltage as a secondary effect.

Note 2 to entry: For a **PTC thermistor**, the significant portion of the resistance/temperature characteristic is usually the portion in which a step-like increase in resistance occurs in a temperature increment, usually preceded by a gradual change in resistance at lower temperatures, and a similar gradual change at temperatures above the step-like increase. The resistance/temperature characteristic of some **PTC thermistors** can take on a negative slope after a slight gradual increase following the step-like increase.

J.2.15.3
NTC thermistor
negative temperature coefficient (**NTC**) **thermistor** that exhibits a decrease in resistance with increasing temperature over the useful portion of the resistance/temperature characteristic

J.2.15.4
thermistor control element
PTC thermistor or **NTC thermistor** which directly controls a load by being connected in series with it

Note 1 to entry: A **control thermistor** is not intended to be connected across the mains.

Note 2 to entry: Typical uses are current limiters, **inrush-current** limiters, degaussing coil-current limiters, and motor starting-current limiters.

J.2.15.5
self-controlled heater
PTC thermistor which has no additional **temperature limiter** and which is used as a heater element because of its self-heating effect

Note 1 to entry: It is typically used across-the-line.

Note 2 to entry: Normally a **self-controlled heater** will provide a **type 2 action**.

J.2.15.6
thermistor sensing element
PTC thermistor or **NTC thermistor** used as a sensor and which does not carry load current

J.2.15.7
B value
NTC thermistor's index, which expresses the degree of resistance change when calculated from any two points specified by the manufacturer on the resistance/temperature (R/T) curve

J.2.15.8
hold current
I_h
maximum current a current limiting **PTC thermistor** is able to maintain in a low resistance "on" state at rated ambient for a period of time specified by the manufacturer

J.2.15.9
inrush current
I_n
peak current measured following energization at rated voltage and at 25 °C ± 2 K or at the manufacturer's specified ambient temperature

J.2.15.10
trip current
I_t
for a current-limiting **PTC thermistor**, minimum current value declared by the manufacturer at which a **PTC thermistor** switches from low to high resistance at a specified temperature or temperature range

Note 1 to entry: $I_t = Y \times I_h$, where Y is the **trip current** multiplier declared by the manufacturer.

J.2.15.11
maximum current
I_{max}
current value assigned by the manufacturer that complies with all the requirements of this standard

Note 1 to entry: For the various devices, the associated current designated as I_{max} is shown in Table J.1.

Table J.1 – Maximum current

Device	Associated current designated I_{max}
PTC **self-controlled heater**	Maximum **steady-state current** [a]
PTC motor starter	Maximum start winding current
PTC current limiter, degausser	Maximum **trip current** [b]
NTC **inrush current** limiter	Maximum steady-state current
PTC or NTC sensor	Not applicable

[a] For devices rated in watts by the manufacturer, I_{max} is calculated. This current does not mean **inrush current**.

[b] For devices assigned a **time-to-trip** versus current curve by the manufacturer, the **maximum current (I_{max})** shall be identified.

J.2.15.12
short-circuit current
I_{sc}
maximum current available from the impedance limited source (such as a power supply)

J.2.15.13
steady-state current
I_{ss}
current measured after a **thermistor's** temperature stabilizes in air at 25 °C ± 2 K ambient temperature, or at an ambient temperature specified by the manufacturer while connected to rated voltage and while operating in its high-resistance state for **PTC thermistors** or low-resistance state for **NTC thermistors**

Note 1 to entry: For some **NTC thermistors**, I_{ss} is the same as I_{max}.

J.2.15.14
resistance
R_{min}
for a ceramic **PTC thermistor**, point of minimum resistance on the R/T curve

J.2.15.15
resistance
R_x (R_{25})
rated **resistance** at a temperature specified by the manufacturer for R_x or at 25 °C ± 2 K for R_{25}

J.2.15.16
switching resistance
R_{sw}
for a ceramic **PTC thermistor**, **resistance** value at which the **resistance** begins to increase sharply with temperature increase

Note 1 to entry: For this standard, R_{sw} is the value where the **resistance** is twice R_{min}; unless the manufacturer specifies R_{sw} with reference to R_{min} with a multiplying factor other than two, or with reference to R_x.

J.2.15.17
tripped resistance
R_{tr}
for a **PTC control thermistor**, **resistance** value of the **thermistor** in its tripped state at **maximum voltage** (V_{max})

Note 1 to entry: R_{tr} is calculated by dividing the voltage drop across the **thermistor** by the **steady-state current** (I_{ss}) flowing through the **thermistor**.

J.2.15.18
switching temperature
T_{sw}
for a ceramic **PTC thermistor**, temperature at which the **resistance** is at R_{sw}

J.2.15.19
surface temperature
T_s
temperature of the surface of a **thermistor** while the **thermistor** is energized under normal operating conditions

Note 1 to entry: Typical normal operating conditions for **thermistors** are specified in Table J.2.

Table J.2 (J.7, 7.2 of edition 3) – Normal operating conditions

Type of thermistor	Voltage	Current
PTC **self-controlled heater**	V_{max}	I_{ss}
PTC motor starter	V_{max}	I_{ss}
PTC degausser	V_{max}	I_{ss}
PTC current-limiter	V_{max}	I_h and I_{ss} [a]
NTC **inrush current** limiter	V_{max}	I_{max}

[a] Surface temperature measured at I_{ss} reflects the conditions in the tripped state of the **thermistor** (normal operating conditions for the PTC, abnormal operating condition for the circuit/application controlled by the PTC).

J.2.15.20
time-to-trip
time required for a **PTC thermistor** to limit the manufacturer's declared **trip current** (I_t) to 50 % of its value when energized at the rated voltage and ambient temperature

J.2.15.21
thermal runaway temperature
T_R
high temperature point on the R/T curve at which a **PTC thermistor's resistance** no longer increases with increasing temperature

J.2.15.22
maximum voltage
V_{max}
maximum voltage of a **thermistor** as declared by the manufacturer

Note 1 to entry: V_{max} is higher than rated voltage (V_r) when a higher operating voltage occurs under certain conditions in the end-use equipment such as for motor starting-coil limiters.

J.4 General notes on tests

J.4.2 Samples required

Additional subclauses:

J.4.2.5 Unless otherwise specified, representative samples as indicated in Table J.3 shall be subjected to the tests specified in J.17.18. New samples shall be used for all tests other than the overload and endurance tests.

Table J.3 – Samples for the test (clause reference)

		Ageing *(J.17.18.3)*	**Heat-cold-humidity cycling** *(J.17.18.1)*	**Overload** *(J.17.18.2.1, J.17.18.7.1)*	**Endurance** *(J.17.18.2.2, J.17.18.7.2)*	**Cold operational cycling** *(J.17.18.4, J.17.18.8)*	**Cold thermal cycling** *(J.17.18.6)*	**Thermal runaway** *(J.17.18.5)*
Number of samples per test		3	3	3 [a]	3 [a]	3	3	3
Thermistor application	PTC **self-controlled heater**	X	X	X	X	X	-	X
	PTC **control**	X	X	X	X	X	-	X
	PTC sensor	X	X	X	X	-	X	-
	NTC **control**	X	X	X	X	X	-	-
	NTC sensor	X	X	X	X	-	X	-
The calibration tests of J.15.7 and J.15.8 shall be conducted before and after each of the above tests (except thermal runaway).								
[a] The same three samples shall be used for both the overload and endurance tests.								

J.4.3.2 According to rating

Additional paragraph:

For the purposes of this standard, the rated voltage (V_r) of a **thermistor** is the input voltage of a **thermistor** as declared by the manufacturer.

NOTE V_r is typically equal to the supply source voltage.

Additional subclause:

J.4.3.2.11 The electrical and thermal ratings of a **thermistor** shall be in accordance with Table J.4 and based on its intended application.

Table J.4 – Electrical and thermal ratings of a thermistor

Characteristic	Thermistor type						
	PTC					NTC	
	Self-controlled heater	Motor starter	Current limiter [a]	Sensor [a]	Degausser	Sensor [a]	Inrush-current limiter
Beta value (B)	-	-	-	-	-	R	-
Calibration class number	-	-	-	R	-	R	-
Capacitance – load, or Joule rating	-	-	-	-	-	-	R
Trip current – (I_t)	-	-	R	-	-	-	-
Inrush current (I_n)	R	R	-	-	R	-	R
Hold current (I_h)	-	-	R	-	-	-	-
Maximum current (I_{max})	-	R	R	-	R	-	R
Steady-state current (I_{ss})	R	R	R	-	R	-	R
Coil impedance	-	-	-	-	R	-	-
Resistance – R_{25} and tolerance	R	R	R	R	R	R	R
Maximum operating ambient temperature	-	R	R	R	R	R	R
Switching temperature (T_{sw})	R	R	R	R	R	-	-
Maximum surface temperature (T_s)	R	R	R	-	R	-	R
Time-to-trip	-	-	R	-	-	-	-
Maximum voltage (V_{max})	R	R	R	-	R	-	R
Rated voltage (V_r)	R	R	R	-	R	-	R
The "R" designation indicates ratings for the device that are required to be provided by the manufacturer.							
[a] The range of operating ambient temperature shall be specified.							

J.4.3.5 According to purpose

Additional subclauses:

J.4.3.5.4 Based on the type of **thermistor** and the particular application, **thermistors** shall be subjected to the tests noted in Table J.3 and the calibration tests of J.15.7 or J.15.8, whichever applies.

J.4.3.5.4.1 Thermistors used in **type 1 action controls** that comply with IEC 60738 or IEC 60539 shall be subjected to the thermal runaway test of J.17.18.5 only. Compliance to IEC 60738-1 or IEC 60539 is not required if the **thermistors** comply with the requirements of Annex J.

J.6 Classification

J.6.4 According to features of automatic action

J.6.4.3.3 *Replacement:*

For the purpose of this standard, a **PTC thermistor control** or **sensing element** that is in the switched mode (high resistance) or an **NTC thermistor** in the unswitched mode (high resistance), are considered to provide the equivalent of **electronic disconnection** and are classified as type 1.YJ action or 2.YJ action.

– **thermistor** (type 1.YJ or 2.YJ)

NOTE See also J.11.4.17.

J.6.15 According to construction

Additional subclauses:

J.6.15.6 Control using NTC or PTC thermistors

J.6.15.7 Ceramic element

J.6.15.8 Polymer element

Additional subclauses:

J.6.17 According to use of the thermistor

J.6.17.1 – **thermistor control element**

J.6.17.1.1 – PTC current limiter

J.6.17.1.2 – PTC motor starter

J.6.17.1.3 – PTC degausser

J.6.17.1.4 – NTC **inrush current** limiter

J.6.17.2 – **self-controlled heater**

J.6.17.3 – **thermistor sensing element**

J.6.17.3.1 – PTC sensor

J.6.17.3.2 – NTC sensor

J.7 Information

Table J.5 provides additional requirements to Table 1.

Table J.5 – Additional items to Table 1

	Information	Clause or subclause	Method
61	According to the construction and use of a **thermistor**	J.6.15, J.6.17	X
62	R/T characteristics, calibration specifications [k]	J.15.7, J.15.8	X
63	R/T characteristics, calibration specifications, **drift** [l]	J.15.7, J.15.8, J.17.17.1	X
64	Number of cycles	J.17.18.2	X
65	Method of R/T measurement	J.15.7.4, J.15.8.3	X
82	PTC current limiters where the maximum current is reduced to less than or equal to 8 A in $\leq$ 5 s.	J.15.7.6.1.1	X
Additional footnotes to Table 1: [k] The R/T characteristics shall be expressed in the form of a curve, a table or various operating points and shall include the declared deviation. [l] Additional declarations may be made at intermediate numbers of cycles for the test of J.17.18.2.			

J.11 Constructional requirements

Additional subclauses:

J.11.3.10 **Thermistors** used in **controls** to provide **functional safety** or as **controls** to provide **functional safety** for a controlled application shall provide **type 2 action** (type 2.YJ), for other applications at least (type 1.YJ).

NOTE Examples of **thermistors** used to provide **functional safety** of a controlled application are temperature sensors for temperature cut-out applications or current limiting PTC devices in non-limited energy circuits.

J.11.4.17 Type 1.YJ or 2.YJ action

A type 1.YJ or type 2.YJ action of a **thermistor** shall operate to provide an inherent change in resistance.

Compliance is checked by the tests of relevant requirements of this Annex J.

J.13 Electric strength and insulation resistance

J.13.2 Electric strength

Modification to footnote c of Table 12:

Add the word "thermistors," *after* "electronic parts".

J.15 Manufacturing deviation and drift

Additional subclauses:

J.15.7 Calibration tests for PTC thermistors

J.15.7.1 *Ceramic **thermistors** are not influenced by the sequence in which the calibration tests of J.15.7.4 to J.15.7.8 are conducted on the samples. However, polymeric types may be influenced due to the nature of the material. Hence, for polymeric types of **thermistors**, it is recommended to perform the test of J.15.7.4 at the end of all the calibration tests.*

J.15.7.2 *In the "as-received" condition, each **PTC thermistor** sample shall be subjected to the tests specified in Table J.6 and shall comply with the criteria for each test as specified in Table J.6.*

J.15.7.3 *Following the tests described in J.17.17 a), the same **PTC thermistor** samples shall be subjected to the tests specified in Table J.6 and shall comply with the criteria for each test as specified in Table J.6. For PTC sensors, the test results shall comply with the criteria for each test as specified in Table J.7.*

Table J.6 – Sequence of calibration and conditioning tests for PTC thermistors

Type of PTC thermistor	Calibration tests performed on samples before the conditioning tests specified in J.17.18 [a]	Compliance criteria designation (before conditioning) [b]	Calibration tests performed on thermistor samples after conditioning tests specified in J.17.18 [a]	Compliance criteria designation (after conditioning) [b]
Self-controlled heater	R/T	A	T_s	D
	T_s		I_n	
	I_n			
Motor starter	R/T	A	T_s	D
	T_s		I_n	
	I_n			
Degausser	R/T	A	T_s	D
	T_s		I_n	
	I_n			
Current limiter	R/T	B	TT	E
	T_s			
	TT			
	I_{ss}			
	I_h			
Sensor	R/T	C	R/T	F

R/T - R/T measurement for PTC **thermistors** – all types (J.15.7.4)

I_h - Hold current test for PTC current limiters (J.15.7.5)

TT - Time-to-trip test for PTC current limiters (J.15.7.6)

T_s - Surface temperature test (J.15.7.7)

I_n - **Inrush current** (compliance is determined by measurement, J.15.7.8)

I_{ss} - Steady-state current (compliance is determined by measurement)

A - Resistance at 25 °C, **surface temperature** and **inrush-current** values shall be within the declared deviation tolerance specified by the manufacturer.

B - Resistance at 25 °C, **surface temperature**, **steady-state current** and **time-to-trip** values shall be within the declared deviation tolerance specified by the manufacturer. The **thermistor** shall maintain the **hold current** for the time at the ambient temperature specified by the manufacturer, without tripping.

C - The temperatures corresponding to the **switching resistance** (R_{sw}) and two additional points, located above and below R_{sw} on the R/T curve shall be within the declared deviation tolerance specified by the manufacturer.

D - The **surface temperature** and **inrush-current** values shall be within the declared **drift** tolerance specified by the manufacturer.

E - Time-to-trip values shall be within the declared **drift** tolerance specified by the manufacturer.

F - The temperatures corresponding to the **switching resistance** (R_{sw}) and two additional points, located above and below R_{sw} on the R/T curve shall not vary from the corresponding as-received values by more than indicated in Table J.7.

[a] Test abbreviations

[b] Compliance criteria

Table J.7 – Classes for PTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature **drift**, K for a given resistance	±0,5	±1,0	±2,0	±5,0
Temperature values should be "normalized" to the Kelvin scale when determining the temperature **drift**.				

J.15.7.4 R/T measurement for PTC thermistors

J.15.7.4.1 ***Thermistor*** *samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within ±1 K of the temperature specified for the test. The test shall be conducted at various temperatures starting at room ambient temperature through the* ***switching temperature*** *(T_{sw}) and not exceeding the* ***thermal runaway temperature*** *(T_R) of the R/T curve. The* ***resistance*** *is be measured by an ohmmeter at as many temperatures as required to create a complete R/T curve.*

J.15.7.5 Hold current (I_h) test for PTC current limiters

J.15.7.5.1 *A current limiting* ***thermistor*** *shall maintain the specified* ***hold current*** *(I_h) for the time specified by the manufacturer at the ambient temperature specified by the manufacturer without tripping.*

J.15.7.6 Time-to-trip test for PTC current limiters

J.15.7.6.1 *A current limiting* ***thermistor*** *with a* ***time-to-trip*** *specification shall trip at the specified* ***trip current*** *(I_t) and corresponding rated voltage (V_r) within the specified* ***time-to-trip****. A* ***thermistor*** *with multiple trip currents and times shall be tested at the maximum and minimum specified currents. The current is not to exceed the* ***maximum current*** *(I_{max}) point on the* ***time-to-trip*** *versus current curve.*

J.15.7.6.1.1 A *current limiting* ***thermistor****, as declared in item 82 of Table J.5, shall trip at the declared* ***trip current*** *(I_t) and corresponding rated voltage (V_r) within the specified* ***time-to-trip****.*

J.15.7.7 Surface temperature test

J.15.7.7.1 *The* ***surface temperature*** *(T_s) of a* ***PTC thermistor*** *shall be measured using thermocouples or equivalent devices. For a* ***PTC thermistor*** *other than a current limiter, the* ***surface temperature*** *(T_s) shall be measured while the* ***thermistor*** *is operating at* ***maximum voltage*** *(V_{max}) and steady-state current. For a PTC current limiter, the* ***surface temperature*** *(T_s) shall be measured under two conditions:*

a) operating condition in hold state where the device shall be operated at its rated ***maximum voltage*** *(V_{max}) and rated* ***hold current*** *(I_h), and*

b) operating condition in tripped state where the device shall be operated at rated ***maximum voltage*** *(V_{max}) and rated* ***steady-state current*** *(I_{ss}).*

See Table J.2.

J.15.7.8 Inrush current measurement

J.15.7.8.1 *For* ***PTC thermistors*** *intended to be used as* ***self-controlled heaters****, motor starters or degaussers, the* ***inrush current*** *shall be measured using an oscilloscope while the* ***thermistor*** *is operating at* ***maximum voltage*** *under rated load.*

J.15.8 Calibration tests for NTC thermistors

J.15.8.1 *In the "as-received" condition, each **NTC thermistor** sample shall be subjected to the tests specified in Table J.8 and shall comply with the criteria for each test as specified in Table J.8.*

J.15.8.2 Following the tests described in J.17.17 b), the same **NTC thermistor** samples shall be subjected to the tests specified in Table J.8 and shall comply with the criteria for each test as specified in Table J.8. For NTC sensors, the test results shall comply with the criteria for as specified in Table J.9.

Table J.8 – Sequence of calibration and conditioning tests for NTC thermistors

Type of NTC thermistor	Calibration tests performed on samples before the conditioning tests specified in J.17.18 [a]	Compliance criteria designation (before conditioning) [b]	Calibration tests performed on thermistor samples after conditioning tests specified in J.17.18 [a]	Compliance criteria designation (after conditioning) [b]
Inrush-current limiter	R/T	A	T_s	C
	T_s		I_n	
	I_n			
Sensor	R/T	B	R/T	D
	Beta			

R/T - R/T measurement for **NTC thermistors** (J.15.8.3)

T_s - Surface temperature test (J.15.8.4)

Beta - **Resistance** (R_{25}) and **beta value** (**B**) test for **NTC thermistors** (J.15.8.6)

I_n - **Inrush current** (compliance is determined by measurement (J.15.8.5)

A - Resistance at 25 °C, **surface temperature**, and **inrush-current** values shall be within the declared deviation tolerance specified by the manufacturer.

B - The **resistance** at two or more temperature points on the R/T curve and the beta value (if declared) shall be within the declared deviation tolerance specified by the manufacturer. One of the temperatures shall be at 25 °C.

C - The **surface temperature** and **inrush-current** values shall be within the declared **drift** tolerance specified by the manufacturer.

D - The **resistance** at two or more temperature points on the R/T curve shall not vary from the respective "as received" temperatures on the "as-received" R/T curve by more than indicted in Table J.9. One of the temperatures shall be 25 °C.

[a] Test abbreviations

[b] Compliance criteria

Table J.9 – Classes for NTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature **drift** for a given resistance	±0,5	±1,0	±2,0	±5,0
Temperature values should be “normalized” to the Kelvin scale when determining the temperature **drift**.				

J.15.8.3 R/T measurement for NTC thermistors

J.15.8.3.1 ***Thermistor*** *samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within ±1 K of the temperature specified for the test. The test shall be conducted at various temperatures, starting at room ambient temperature and not exceeding the maximum declared sensing temperature (sensors) or the maximum **surface temperature** (T_s) determined in accordance with J.15.8.4*

*(**inrush-current** limiters). The **resistance** shall be measured at as many temperatures as required to create a complete R/T curve.*

J.15.8.4 Surface temperature test (inrush-current limiting only)

J.15.8.4.1 *The **surface temperature** (T_S) of a NTC **inrush-current** limiter shall be measured using thermocouples or equivalent devices while the **NTC thermistor** is being operating at **maximum voltage** (V_{max}) and **maximum current** (I_{max}) with the rated capacitance value in parallel with the load. The temperature shall be within the manufacturer's specified limits. See Table J.8.*

J.15.8.5 Inrush current measurement (inrush-current limiting only)

J.15.8.5.1 For an NTC **inrush-current** limiter, the **inrush current** shall be measured using an oscilloscope while the **thermistor** is operating at **maximum voltage** (V_{max}) and **maximum current** (I_{max}) with the rated capacitance value in parallel with the load.

J.15.8.6 Resistance (R_{25}) and beta value (B) test for NTC thermistors

J.15.8.6.1 *The **beta value** (B) of a **thermistor** with a **beta value** (B) rating shall be within the limits specified by the manufacturer. The **resistance** (R_{25}) of a **NTC thermistor** shall be measured at 25 °C followed by measurement of resistances R_1 and R_2 at temperatures T_1 and T_2 as specified by the manufacturer. The **beta value** (B) shall be calculated using the following formula:*

$$B = (I_n R_1 - I_n R_2) / (1/T_1 - 1/T_2)$$

where

B *is the calculated beta value,*

R_1 *is the **resistance** at* T_1,

R_2 *is the **resistance** at* T_2,

T_1 *is a temperature in K on the* R/T *curve specified by the manufacturer, and*

T_2 *is a second temperature in K on the* R/T *curve specified by the manufacturer.*

J.17 Endurance

Additional subclauses:

J.17.17 The sequence of tests is as follows:

*a) for **PTC thermistors**:*

- *Ageing (J.17.18.3.1or J.17.18.3.2);*
- *Heat-cold-humidity (J.17.18.1);*
- *Overload (J.17.18.2.1);*
- *Endurance (J.17.18.2.2);*
- *Cold operational cycling (J.17.18.4);*
- *Cold thermal cycling (J.17.18.6);*
- 〚C〛 *Thermal runaway by increased voltage* 〚C〛 *(J.17.18.5).*

b) *for **NTC thermistors**:*

- *Ageing (J.17.18.3.1);*
- *Heat-cold-humidity (J.17.18.1);*
- *Overload (J.17.18.7.1);*

– *Endurance (J.17.18.7.2);*

– *Cold operational cycling (J.17.18.8);*

– *Cold thermal cycling (J.17.18.6).*

J.17.17.1 *After the appropriate tests of J.17.18.1 to J.17.18.4 inclusive, the performance of the **control** shall not be adversely affected and it shall function as intended and declared. Compliance is checked by the tests of J.15.7 or J.15.8, whichever applies.*

J.17.17.2 *After the appropriate tests of J.17.18, the **control** shall continue to comply with the requirements of Clauses 8 and 13. During and after the tests, there shall be no emission of flames or expulsion of particles.*

J.17.18 Conditioning tests

J.17.18.1 Heat-cold-humidity

Following the conditioning specified in J.17.18.1.1, a **thermistor** shall comply with Tables J.6, J.7, J.8 or J.9, whichever applies.

J.17.18.1.1 *Three non-energized samples of a **thermistor** shall be subjected to three complete cycles in the sequence specified in a) or b):*

a) Indoor temperature use:

*1) 24 h at the measured **surface temperature** (T_s) or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The temperature shall be monitored within the area of the oven in which the samples are being tested;*

2) 168 h in a non-condensing atmosphere having a relative humidity of 90 % to 95 % at 40 °C; and

3) 8 h at 0 °C or at the manufacturer's specified ambient temperature, whichever is lower.

b) Outdoor temperature use:

1) 24 h immersed in water at 25 °C;

2) 8 h at minus 35 °C or at the manufacturer's specified ambient temperature, whichever is lower;

*3) 24 h at the measured **surface temperature** (T_s) or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The oven temperature shall be monitored within the area of the oven in which the samples are being tested; and*

4) 168 h in a non-condensing atmosphere having a relative humidity of 90 % to 95 % at 40 °C.

J.17.18.2 Extended cycling (PTC)

J.17.18.2.1 Overload

J.17.18.2.1.1 Following the tests specified in J.17.18.2.1.2, J.17.18.2.1.3, or J.17.18.2.1.4 and J.17.18.2.2.1, a **thermistor** shall comply with Table J.6 or Table J.7.

J.17.18.2.1.2 *For a **self-controlled heater**, three samples shall be mounted and operated as intended for 50 cycles while connected to 120 % of **maximum voltage** (V_{max}). Each cycle shall cover that portion of the R/T curve from the lower knee to the high **resistance** state.*

J.17.18.2.1.3 *For a **control thermistor**, three samples shall be mounted and operated as intended for 50 cycles while connected to **maximum voltage** (V_{max}) and the lesser value of:*

*a) 120 % of rated **maximum current** (I_{max}), or*

*b) 120 % of rated **short-circuit current** (I_{sc}).*

*Each cycle shall start with the sample thermally stabilized at 25 °C ± 5 K. Each cycle shall cover that portion of the R/T curve from the lower knee to the high **resistance** state.*

J.17.18.2.1.4 *For a sensing **thermistor**, three samples shall be mounted and operated as intended for 50 cycles of **operation** consisting of starting with the sample thermally stabilized at 25 °C ± 5 K and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.*

J.17.18.2.2 Endurance

J.17.18.2.2.1 *The three **thermistor** samples that have been subjected to overload test of J.17.18.2.1, shall be operated at the conditions specified in a), b), or c) for the number of cycles specified in Table J.10. Each cycle shall cover a significant portion of the R/T curve.*

*a) **Self-controlled heater** – A **self-controlled heater thermistor** or heater assembly shall be mounted and tested at **maximum voltage** (V_{max}) maximum rated wattage or maximum current (I_{max}). A **thermistor**, whose power consumption varies with the amount of heat sinking, air flow, or similar variables provided in the end-use equipment, shall be tested at the maximum rated wattage or **maximum current** (I_{max}) using the heat sinking, air flow, or other conditions of the end-use equipment.*

*b) Control – A control **thermistor** shall be tested at **maximum voltage** (V_{max}) and the following currents:*

   1) Current limiter – The test current shall not be less than the minimum tripping current (I_t) or the minimum functioning current (I_{fun}).

   *2) Degausser – The test current shall be **maximum current** (I_{max}).*

   *3) Motor starter – The test current shall be **maximum current** (I_{max}).*

*c) Sensing – A sensing **thermistor** shall be cycled between 25 °C ± 5 K and the maximum operating temperature.*

Table J.10 – Number of cycles for endurance test

Type of thermistor	Number of cycles of operation
Self-controlled heater	100 000
Current limiter intended for use in a **functional safety** circuit	100 000 [a]
Current-limiter not intended for use in a **functional safety** circuit	6 000
Degausser or motor starter	30 000
Sensor not intended for use in a **functional safety** circuit	6 000
Sensor intended for use in a **functional safety** circuit	100 000

[a] The minimum number of cycles is reduced to 6 000 under the following conditions:
- the trip state of the **thermistor** is apparent in the end-use application; and
- manual intervention is required in order to reset the **thermistors**.

J.17.18.3 Thermal conditioning

J.17.18.3.1 Passive ageing

*Following the conditioning specified in J.17.18.3.1.1 and J.17.18.3.2.1, a **thermistor** shall comply with Tables J.6, J.7, J.8 or J.9, as appropriate.*

J.17.18.3.1.1 *Three non-energized samples of a **thermistor** shall be conditioned for 1 000 h at a temperature 30 K above the temperature specified in Table J.11 in an air-circulating oven. In any case the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The oven temperature shall be monitored within the area of the oven in which the samples are being tested.*

Table J.11 – Ageing test temperature

Thermistor type	Temperature
All types except sensors	Temperature determined in accordance with **surface temperature** test, J.15.7.7 (PTC) and J.15.8.4 (NTC)
Sensing	Highest temperature rating

J.17.18.3.2 Active ageing

J.17.18.3.2.1 *In addition to the test described in J.17.18.3.1.1, a current limiter shall be subjected to this test. Three samples of a current limiting **PTC thermistor** shall be energized and conditioned for 1 000 h while in the tripped state at **maximum voltage** (V_{max}) and carrying **steady-state current** (I_{ss}).*

J.17.18.4 Cold operational cycling (PTC)

J.17.18.4.1 *Following the test specified in J.17.18.4.2, a **thermistor** shall comply with Table J.6.*

J.17.18.4.2 *Three samples of a **thermistor** shall be subjected to 1 000 cycles of **operation** at an ambient temperature of 0 °C or at the manufacturer's specified ambient, whichever is lower. The test conditions shall be as specified in J.17.18.2.2.1 a) for a **self-controlled heater** or J.17.18.2.2.1 b) for a **control thermistor**. The **thermistor** temperature shall be returned to the starting temperature before each cycle.*

J.17.18.5 〚C〛 Thermal runaway by increased voltage 〚C〛

*The **thermistors** are to be energized and operated under maximum rated conditions until thermally stabilized. The voltage is then to be gradually increased until breakdown occurs, or two times the **working voltage** of the **thermistor** is reached, at which time the test may be terminated.*

NOTE Increasing the voltage in steps of 0,1 times the **working voltage** of the **thermistor** every 2 min constitutes an appropriate rate of rise.

J.17.18.6 Cold thermal cycling

J.17.18.6.1 *Following the cycling specified in J.17.18.6.1.1, a **thermistor** shall comply with Tables J.7 or J.9, whichever applies.*

J.17.18.6.1.1 *Three samples of a sensing **thermistor** shall be subjected to 1 000 cycles of cold thermal cycling **operation**. Each cycle shall start at 0 °C or at the manufacturer's specified ambient, whichever is lower, and cover that portion of the R/T curve from the starting temperature to the maximum rated temperature.*

J.17.18.7 Extended cycling (NTC)

J.17.18.7.1 Overload

J.17.18.7.1.1 *Following the tests specified in J.17.18.7.1.2 or J.17.18.7.1.3 and J.17.18.7.2.1, a **thermistor** shall comply with Table J.8.*

J.17.18.7.1.2 *For an **inrush-current** limiting **thermistor**, three samples shall be mounted and operated as intended for 50 cycles while connected to **maximum voltage** (V_{max}) and 120 % of the **maximum current** (I_{max}). Each cycle shall start with the sample thermally stabilized at 25 °C.*

J.17.18.7.1.3 *For a sensing **thermistor**, three samples shall be mounted and operated as intended for 50 cycles of **operation** consisting of starting with the sample thermally stabilized at 25 °C ± 5 K and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.*

J.17.18.7.2 Endurance

J.17.18.7.2.1 *The three **thermistor** samples that have been subjected to the overload test, J.17.18.7.1, shall be operated at the conditions specified in a) or b) for the number of cycles specified in Table J.12. Each cycle shall cover a significant portion of the R/T curve.*

a) ***Inrush-current** limiting – An **inrush-current** limiting **thermistor** shall be tested at **maximum voltage** (V_{max}) and maximum current (I_{max}) with the rated capacitance value in parallel with the load. See Figure J.1.*

b) *Sensing – A sensing **thermistor** shall be cycled between 25 °C ± 5 K and the maximum operating temperature.*

Table J.12 – Number of cycles for endurance test

Type of thermistor	Number of cycles of operation
Inrush-current limiter intended for use in a **functional safety** circuit	100 000
Inrush-current limiter not intended for use in a **functional safety** circuit	6 000
Sensor intended for use in a **functional safety** circuit	100 000
Sensor not intended for use in a **functional safety** circuit	6 000

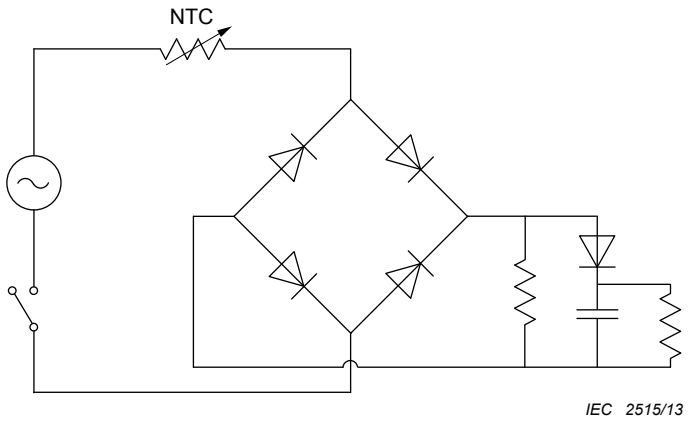


Figure J.1 – Test circuit for inrush-current limiting thermistor endurance test

J.17.18.8 Cold operational cycling (for inrush current-limiting NTC thermistors only)

J.17.18.8.1 Following the cycling specified in J.17.18.8.2, a **thermistor** shall comply with Table J.8.

J.17.18.8.2 *Three samples of a **thermistor** shall be subjected to 1 000 cycles of **operation** at **maximum voltage** (V_{max}) conducting **maximum current** (I_{max}), at an ambient temperature of 0 °C or at the manufacturer's specified ambient temperature, whichever is lower. Each cycle shall cover that portion of the R/T curve from the starting temperature to steady-state conditions. The **thermistor** temperature shall be stabilized at the start temperature ±2 K before each cycle.*

J.20 Creepage distances, clearances and distances through insulation

Additional subclauses:

J.20.1.14 Clearance

J.20.1.14.1 Clearance between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of 20.1.

J.20.1.14.2 Clearance between **live parts** providing **functional insulation** shall comply with the requirements of 20.1.

J.20.2.5 Creepage distance

J.20.2.5.1 Creepage distance between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of 20.2.

J.20.2.5.2 Creepage distance between **live parts** providing **functional insulation** shall comply with the requirements of 20.2.

J.24 Components

J.24.2.1 *Add the following:*

Subclause J.24.2.1 is applicable to **thermistors** previously tested under IEC 60738-1, IEC 60738-1-1 or IEC 60539.

J.27 Abnormal operation

J.27.1 Consideration of **fault** modes shall be made in accordance with Table H.24 for **thermistors** used in **protective controls**.

Annex K
(informative)

Nominal voltages of supply systems for different modes of overvoltage control

Nominal voltages of supply systems for different modes of overvoltage control are as indicated in Table K.1 and Table K.2.

Table K.1 – Inherent control or equivalent protective control

Voltage line-to-neutral from nominal voltages a.c. or d.c. [a]	Nominal voltages presently used in the world				Rated impulse voltage for equipment [a]			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems a.c. or d.c.	Single-phase three-wire systems a.c. or d.c.	Overvoltage category			
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30 / 60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	〖C〗 *Text deleted* 〖C〗 127 / 220	115; 120; 127	110; 120	110 / 220 〖C〗120 / 240 〖C〗	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277; 347; 380; 400; 415; 440; 480	220	220 / 440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	500; 577; 600	480	480 / 960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] These columns are taken from Annex F, Table F.1 of IEC 60664-1:2007 in which the **rated impulse voltage** values are specified. See 4.2.3 of IEC 60664-1:2007 for the definitions of protective **control** and inherent **control**.

〖C〗 *Text deleted* 〖C〗

Table K.2 – Cases where protective control is necessary and control is provided by surge arresters having a ratio of clamping voltage to rated voltage not smaller than that specified by IEC 60099-1

Voltage line-to-neutral from nominal voltages a.c. or d.c. [a]	Nominal voltages presently used in the world				Rated impulse voltage for equipment [a]			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems a.c. or d.c.	Single-phase three-wire systems a.c. or d.c.	V			
					Overvoltage category			
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30/60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	〖C〗 *Text deleted* 〖C〗 127 / 220	115; 120; 127	110; 120	110/220 120/240	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277	220	220/440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	347; 380; 400; 415; 440; 480; 500; 577; 600	480	480/960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] These columns are taken from Annex F, Table F.1 of IEC 60664-1:2007 in which the **rated impulse voltage** values are specified. See 4.2.3 of IEC 60664-1:2007 for the definitions of protective **control** and inherent **control**.

〖C〗 *Text deleted* 〖C〗

Annex L
(normative)

Overvoltage categories

Overvoltage category is a numeral characterizing a **transient overvoltage** condition.

The following information on **overvoltage categories** is based on IEC 60664-1. Part 2s may specify a different **overvoltage category** for particular applications.

Equipment of **overvoltage category** IV is for use at the origin of the installation.

NOTE 1 Examples of such equipment are electricity meters and primary overcurrent protection equipment.

Equipment of **overvoltage category** III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements.

NOTE 2 This category normally applies to **controls** intended for connection to **fixed wiring** or for incorporation into equipment intended for permanent connection to **fixed wiring**, unless the **control** or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

Equipment of **overvoltage category** II is energy consuming equipment to be supplied from the fixed installation.

NOTE 3 This category normally applies to **controls** not provided with terminals for **fixed wiring**, or connected after a socket-outlet, or for incorporation into equipment connected after a socket-outlet. **Controls** intended for permanent connection to **fixed wiring** can also come into this category, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or **clearances** between conductive parts are incorporated in the **control** or equipment. Where the contacts of a **control** are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this can provide adequate suppression; for example, **controls** for household appliances satisfying the above descriptions.

If such equipment is subjected to special requirements with regard to reliability and availability, **overvoltage category** III applies.

Equipment of **overvoltage category** I is equipment for connection to circuits in which measures are taken to limit **transient overvoltages** to an appropriately low level.

NOTE 4 This category normally applies to **controls** connected after category II equipment and which, for example, includes electronic logic systems, **isolated limited secondary circuits**, **SELV**-circuits or PELV-circuits, and circuits on the secondary side of a transformer.

Annex M
(informative)

Typical usage

Table M.1 – Typical usage

Control situation	Overvoltage category			
	I	II	III	IV
Special **Isolated limited secondary circuit** Transient limited supply	 X X	 X	 X	 X
Energy consuming utilization equipment				
Integrated and **incorporated controls** in household appliances		X		
Independently mounted controls for fixed-wiring to energy consuming loads		X	X	
Other household and similar applications:				
Controls which are not integrated, incorporated, or for fixed-wiring to energy consuming loads			X	
Controls mounted at the origin of installation (i.e. service entrance equipment, electricity meters and primary overcurrent equipment)				X
Controls covered by special part 2 considerations	X	X	X	X

Annex N
(normative)

Pollution degrees

N.1 Pollution

The **micro-environment** determines the effects of **pollution** on the insulation. The **macro-environment**, however, has to be taken into account when considering the **micro-environment**.

Means may be provided to reduce **pollution** at the insulation under consideration by the effective use of coatings, enclosures, encapsulation or hermetic sealing. Such means to reduce **pollution** may not be effective when the equipment is subject to condensation or if, in normal **operation**, it generates pollutants itself.

Small **clearances** can be bridged completely by solid particles, dust and water and therefore minimum **clearances** are specified where **pollution** may be present in the **micro-environment**.

NOTE 1 **Pollution** will become conductive in the presence of humidity. **Pollution** caused by contaminated water, soot, metal or carbon dust is inherently conductive.

NOTE 2 Conductive **pollution** by ionized gases and metallic depositions occurs only in specific instances, for example, in arc chambers of switchgear or controlgear and is not covered by this standard.

N.2 Degrees of pollution in the micro-environment

For the purpose of evaluating **creepage distances** and **clearances**, the following four degrees of **pollution** in the **micro-environment** are established:

– **Pollution degree** 1

No **pollution** or only dry, non-conductive pollution occurs. The **pollution** has no influence.

NOTE 1 Special considerations (for example, coating evaluated to Annex P or Annex Q, sealed enclosure) are necessary to establish **pollution degree** 1.

– **Pollution degree** 2

Only non-conductive **pollution** occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

NOTE 2 **Pollution degree** 2 is representative of normal household air circulation.

NOTE 3 **Pollution** from the operation of contacts is classified as **pollution degree** 2 unless the area is affected by other **pollution**, in which case the **pollution degree** corresponding to the other **pollution** applies.

– **Pollution degree** 3

Conductive **pollution** occurs or dry non-conductive **pollution** occurs which becomes conductive due to condensation which is to be expected.

– **Pollution degree** 4

The **pollution** generates persistent conductivity caused by conductive dust or by rain or snow.

Annex P
(normative)

Printed circuit board coating performance test

P.1 A coating intended to be used on a printed circuit board that has **creepage distances** in accordance with Clause 20, **pollution degree** 1, shall comply with the requirements of Annex P.

P.2 A printed circuit board assembly that is used with a coating, including inks, solder resists and assembled components, is to be acceptable for its application in terms of temperature, solder conditions, conductor size and adhesion to the base material as determined by the requirements of IEC 61249 series.

P.3 Electric strength of coating – A coating shall withstand the electric strength test of 13.2 for **functional insulation** at a test voltage determined from Table 12, based on the maximum **working voltage** supplied to the board assembly, after the conditioning of P.3.3 and P.3.4.

P.3.1 Ten test samples shall be prepared with the minimum applicable **creepage distances** and the minimum coating thickness using the pattern shown in Figure P.1. The samples are to be prepared by normal production means using the primer or cleaner employed prior to applying the coating to the board. Wiring suitable to the voltages and temperatures involved is to be attached.

P.3.2 Ageing test – Five samples of the coated board as described in P.3.1 shall be subjected to a temperature of 130 °C ± 2 K for 1 000 h.

P.3.3 Humidity conditioning – The five samples of the coated board which were subjected to the ageing test of P.3.2 are to be conditioned for 48 h in a test chamber at a temperature of (35 ± 1) °C and (90 ± 5) % relative humidity. Immediately following removal from the test chamber, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

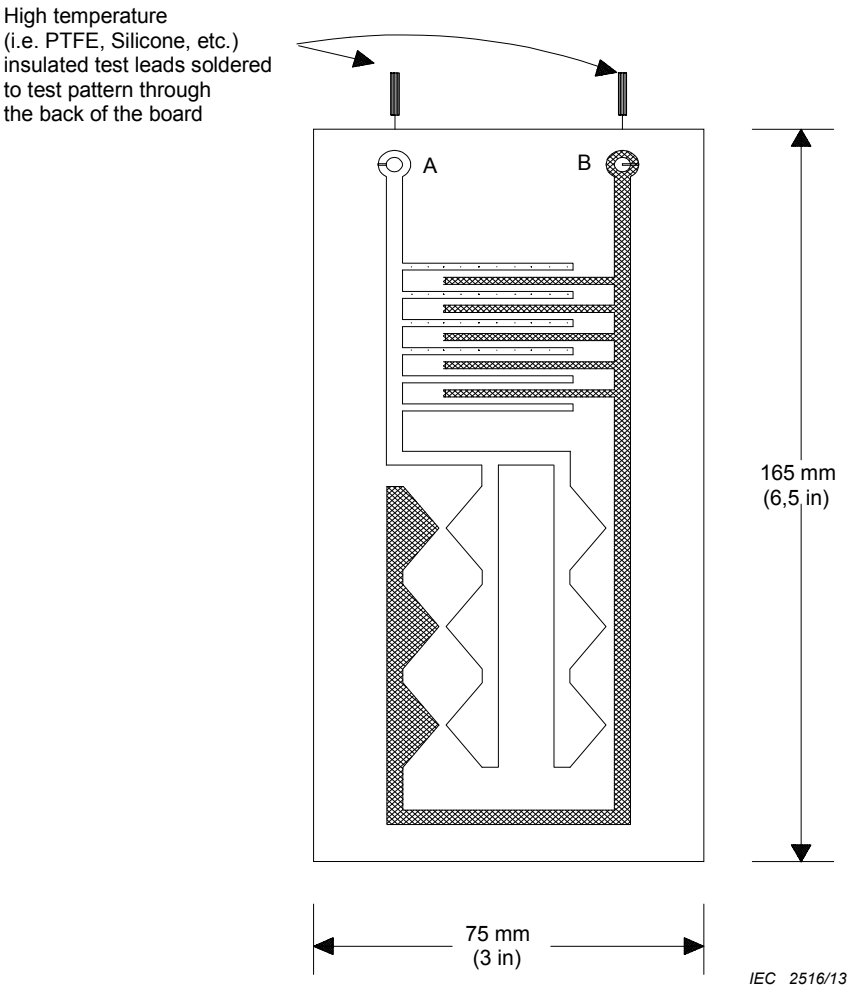
P.3.4 Environmental cycle conditioning – Five of the samples of the coated board described in P.3.1 are to be subjected to three complete cycles of environmental conditioning as described in Table P.1. Immediately following the conditioning, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

P.3.5 After conditioning, the samples of the coated board as described in P.3.1 are to be provided with tight-fitting aluminium foil (representing an electrically conductive deposit along the surface of the coating) that covers the test pattern except for the insulated test lead wire and solder points.

P.3.6 The voltage stress is to be applied according to Clause P.3 to each conditioned sample between leads A, B, and C individually and the common lead (see Figure P.1). No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

Table P.1 – Environmental cycling conditions

For indoor applications	For outdoor applications
24 h at T_{max}; followed by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (0 ± 2) °C	A minimum of 24 h immersed at (25 ± 2) °C; followed immediately by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (–35 ± 2) °C



NOTE The smallest distance between tracks (point-to-point, point-to-line and line-to-line) represents the minimum distance to be permitted on production assemblies.

Figure P.1 – Test sample

Annex Q
(normative)

Printed circuit board coating performance test

Q.1 A printed wiring board conforming with all of the requirements for type 1 coating as specified in IEC 60664-3 shall comply with the minimum **creepage distance** requirements of Clause 20 of this standard, **pollution degree** 1.

Q.2 A printed wiring board conforming with all of the requirements for type 2 coating as specified in IEC 60664-3 shall comply with the minimum requirements for solid insulation as specified in 20.3 of this standard. The spacing between the conductors before the protection is applied shall not be less than the values as specified in Table 1 of IEC 60664-3:2003.

Q.3 Actual printed boards representative of production samples or standard test boards according to Figures Q.1 and Q.2 may be used for the tests. Thirteen samples are required for type 1 tests, seventeen samples for type 2 tests.

Q.4 *Compliance with the requirements for type 1 or type 2 coating shall be checked by the tests of Clause 5 of IEC 60664-3:2003, Amendment 1:2010.*

Q.5 For the tests of Clause 5 of IEC 60664-3:2003, Amendment 1:2010, the test levels or conditions given in Table Q.1 apply:

Table Q.1 – IEC 60664-3 test levels or conditions

IEC 60664-3:2003, subclause		Test level of this standard
5.7.1	Cold storage	–25 °C
5.7.3	Rapid change of temperature	Degree of severity 2 (–25 °C to +125 °C)
5.7.4.2	Electromigration	Not applicable unless specified in part 2
5.8.5	Partial discharge	Not applicable unless specified in part 2

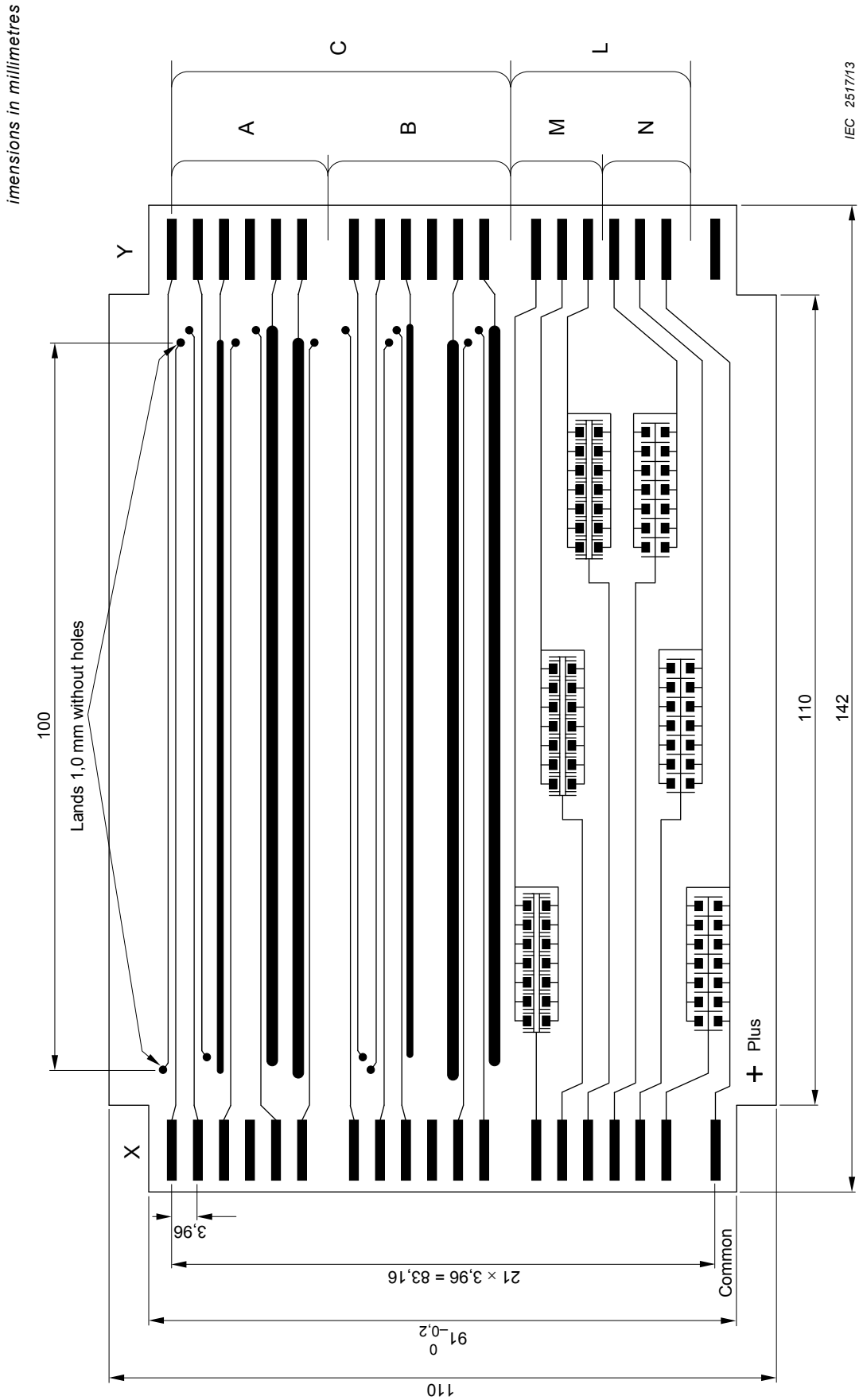


Figure Q.1 – Test sample

Dimensions in millimetres

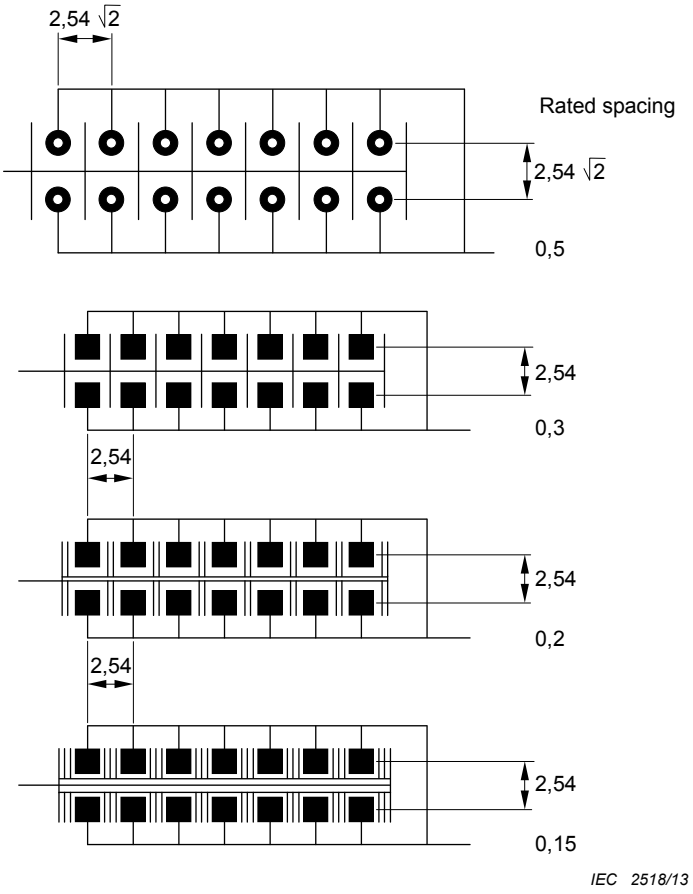


Figure Q.2 – Examples of land configurations
(see also Figure Q.1)

Annex R
(informative)

Explanatory notes for surge immunity test

R.1 Different source impedances

The selection of the source impedance of the generator depends on:

– the kind of cable/conductor/line (power supply a.c., power supply d.c., interconnection, etc.);
– the length of the cables/lines;
– indoor/outdoor conditions;
– application of the test voltage (line-to-line or line-to-earth).

The impedance of 2 Ω represents the source impedance of the low voltage power supply network.

The generator with its effective output impedance of 2 Ω is used.

The impedance of 12 Ω (10 Ω + 2 Ω) represents the source impedance of the low voltage power supply network and earth.

The generator with an additional resistor of 10 Ω in series is used.

The impedance of 42 Ω (40 Ω + 2 Ω) represents the source impedance between all other lines and earth.

The generator with an additional resistor of 40 Ω in series is used.

R.2 Application of the tests

Two different kinds of tests are to be distinguished: at equipment level and at **system** level.

R.2.1 Equipment level immunity

The test shall be carried out in the laboratory on a single EUT. The immunity of the EUT thus tested is referred to as equipment level immunity.

The test voltage shall not exceed the specified capability of the insulation to withstand high voltage stress.

R.2.2 System level immunity

The test carried out in the laboratory refers to the EUT. The equipment level immunity does not assure the immunity of a **system** in all cases. For that reason, a test on **system** level is advised which simulates the real installation. The simulated installation comprises protection devices (arrestors, varistors, shielded lines, etc.) and the real length and type of the interconnection lines.

This test is aimed at simulating as closely as possible the installation conditions in which the EUT or EUTs are intended to function later on.

In the case of the immunity under real installation conditions, higher test levels can be applied, but the energy involved will be limited by the protective devices according to their current limiting characteristics.

The test is also intended to show that secondary effects produced by the protective devices (change of waveform, mode, amplitude of voltages or currents) do not cause unacceptable effects on the EUT.

R.3 Installation classification

R.3.1 General

Installation classifications are as follows:

Class 2: Electrical **environment** where cables are well separated, even on short runs.

The installation is earthed via a separate earth line to the earthing system of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning. The power supply to the electronic equipment is separated from other circuits, mostly by a special transformer for the power supply. Non-protected circuits are in the installation, but well separated and in restricted numbers.

This class applies to category I equipment. Category I normally applies to **controls** connected after category II equipment and which, for example, includes **ELV** electronic logic systems, **isolated limited secondary circuits**, **ELV**-circuits, **SELV**-circuits, PELV-circuits and circuits on the secondary side of a transformer.

Surge may not exceed 1 kV.

Class 3: Electrical **environment** where power and signal cables run in parallel.

The installation is earthed to the common earthing system of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning.

Current due to earth **faults**, switching operations and lightning in the power installation may generate interference voltages with relatively high amplitudes in the earthing system. Protected electronic equipment and less sensitive electric equipment are connected to the same power supply network. The interconnection cables can be partly routed as outdoor cables but close to the earthing network. Unsuppressed inductive loads are in the installation and usually there is no separation of the different field cables.

This class applies to category III or category II equipment.

Category III normally applies to **controls** intended for connection to **fixed wiring** or for incorporation into equipment intended for permanent connection to **fixed wiring**, unless the **control** or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

Category II normally applies to **controls** connected after a socket-outlet or for incorporation into equipment connected after a socket-outlet. **Controls** intended for permanent connection to **fixed wiring** may also come into this category, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or **clearances** between conductive parts, are incorporated in the **control** or equipment. Where the contacts of a **control** are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this may provide adequate suppression. For example, **controls** for household appliances satisfying the above descriptions.

Surge may not exceed 2 kV.

Class 4: Electrical **environment** where the interconnections are running as outdoor cables along with power cables, and cables are used for both electronic and electric circuits.

The installation is connected to the earthing system of the power installation which can be subjected to interference voltages generated by the installation itself or by lightning. Currents in the kiloamperes range due to earth **faults**, switching operations and lightning in the power supply installation may generate interference voltages with relatively high amplitudes in the earthing system. The power supply network can be the same for both the electronic and the electric equipment. The interconnection cables may run as outdoor cables even to the high voltage equipment.

A special case of this **environment** is when the electronic equipment is connected to the telecommunication network within a densely populated area. There is no systematically constructed earthing network outside the electronic equipment and the earthing system consists of pipes, cables, etc. only.

Surge may not exceed 4 kV.

Examples of the installation of electronic equipment in different areas are given in Figures R.1, R.2, and R.3.

R.3.2 Equipment level immunity of ports connected to the power supply network

The minimum immunity level for connection to public supply network is:

Line-to-line coupling: 0,5 kV

Line-to-earth coupling: 1 kV

R.3.3 Equipment level immunity of ports connected to interconnection lines

Surge tests on interconnection circuits are only required for external connections (outside the cabinet/housing). If it is possible to test at the **system** level (EUT with interconnection cables connected) it is not necessary to test at the equipment level (for example, ports of the process-control/signal inputs/outputs) especially in cases where the shield of the interconnection cable is part of protection measures. If the installation of the plant is carried out by someone other than the manufacturers of the equipment, the admissible voltage for the inputs/outputs (especially for the process-control interface) of the EUT should be specified.

The manufacturer should test his equipment on the basis of the specified test levels to confirm the equipment level immunity, for example, with secondary protection at the ports of the EUT for a test level of 0,5 kV. The **user** of the plant or those responsible for the installation should then apply measures (for example, shielding, bonding, earthing, protection) necessary to ensure that the interface voltage caused by, for example, lightning strokes does not exceed the chosen immunity level.

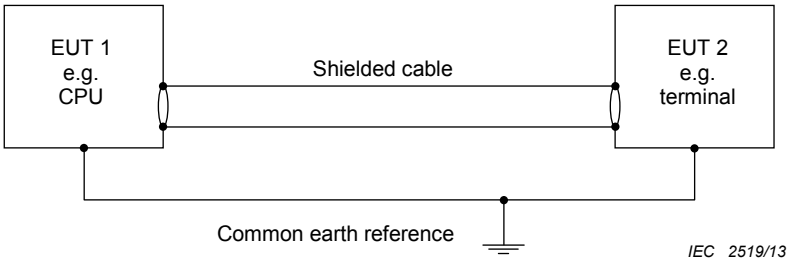


Figure R.1 – Example of surge protection by shielding in buildings with common earth reference systems

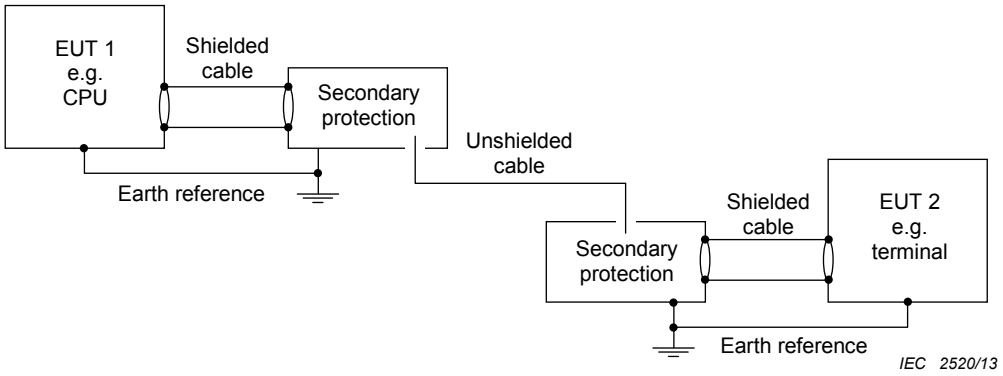


Figure R.2 – Example of secondary surge protection in buildings with separate common earth reference systems

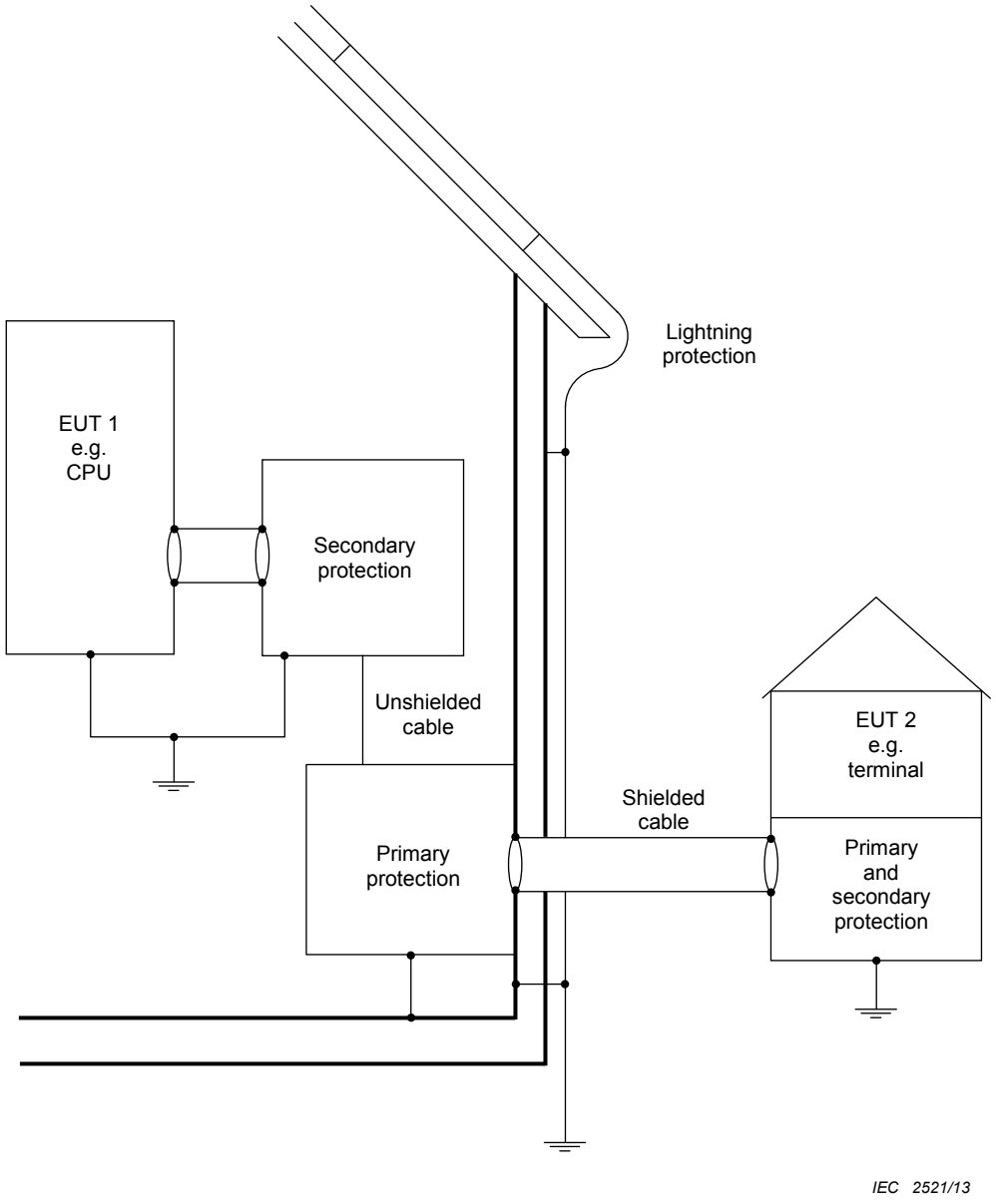


Figure R.3 – Example of primary and secondary surge protection of indoor/outdoor equipment

Annex S
(informative)

Guidance for applying Clause 20

Guidance for applying Clause 20 is indicated in Figure S.1, Table S.1 and Table S.2.

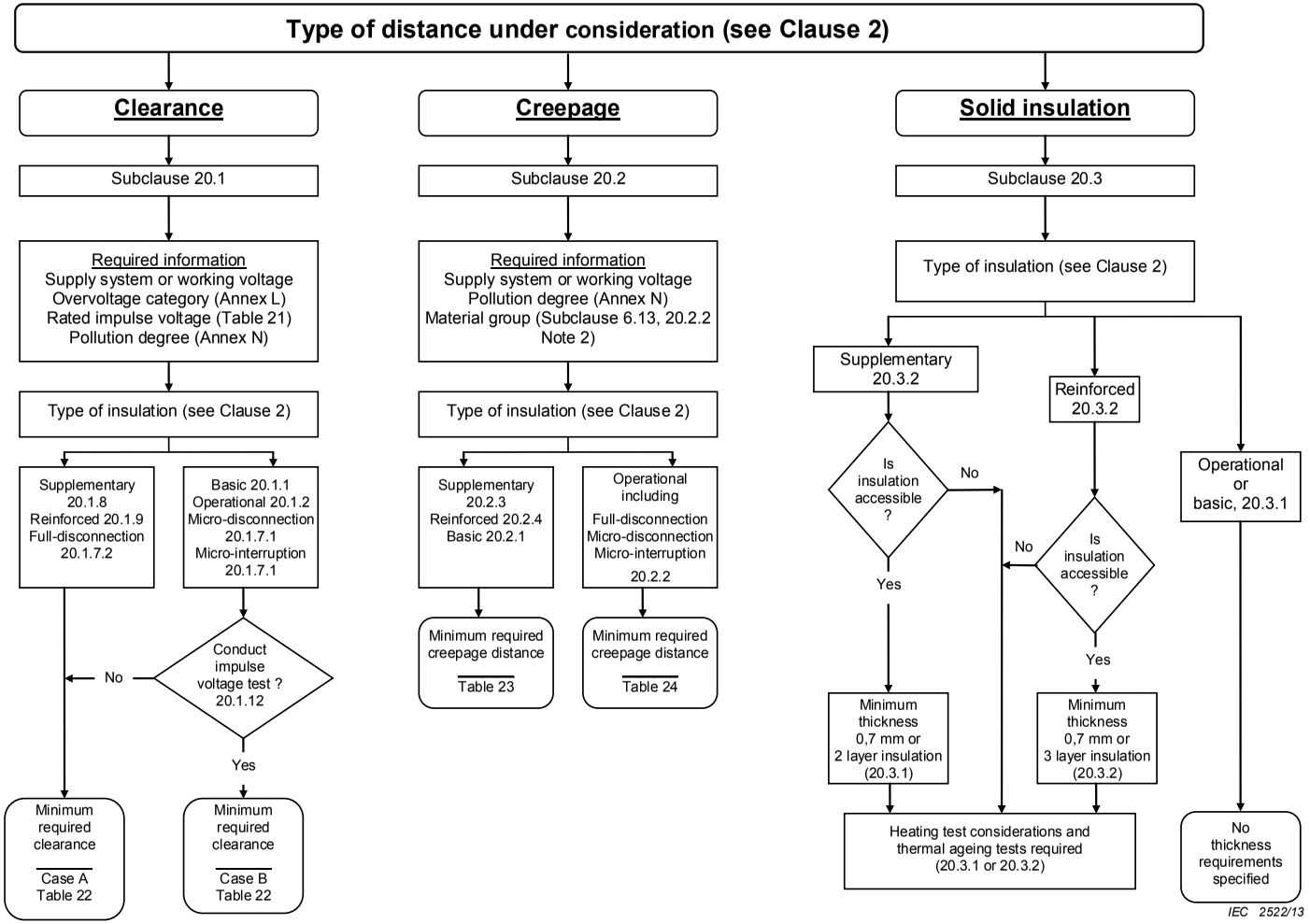


Figure S.1 – Guidance flowchart for application of requirements of Clause 20

Table S.1 – Example A – Using Annex S guidance for applying Clause 20

Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Through air	Follow **clearance** path of flow chart
What is the **system** supply voltage, or for **functional insulation**, the **working voltage**?	230 V/400 V, 3-phase, 4 wire	Record as a)
What is the **overvoltage category**? (refer to Annex L)	See category II	Record as b)
What is the **rated impulse voltage**?	Determine from Table 21 using a) and b)	Record as c)
What is the **pollution degree**? (refer to Annex N)	**Pollution degree** 2	Record as d)
What is the type of insulation? (refer to definitions, etc.)	**Reinforced insulation**	Refer to 20.1.9. For reinforced use case A and next higher impulse voltage step from Table 22. Record as e).
What is the limit for this distance?	Refer to Table 22	Determine the limit using d) and e)
	The limit is 3 mm	

Table S.2 – Example B – Using Annex S guidance for applying Clause 20

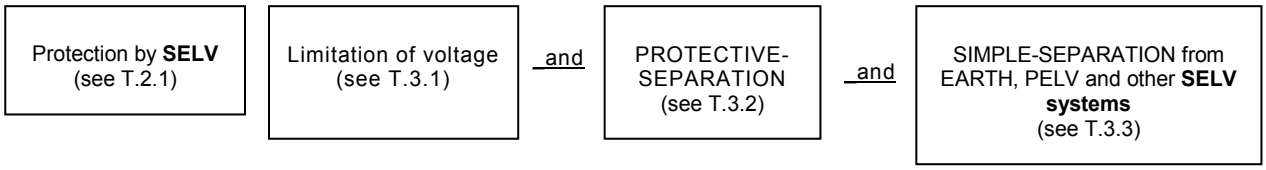
Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Across a surface	Follow **creepage distance** path
What is the **system** supply voltage, or for **functional insulation**, the **working voltage**?	230 V	Record as a)
What is the **pollution degree**? (refer to Annex N)	**Pollution degree** 2	Record as b)
What is the material group? (refer to 20.2.2, Note 2)	IIIb)	Record as c)
What is the type of insulation? (refer to definitions, etc.)	**Functional insulation**	Refer to 20.2.2
What is the limit for this distance?	Refer to Table 24	Determine the limit using a), b) and c)
	The limit is 2,5 mm	

Annex T
(normative)

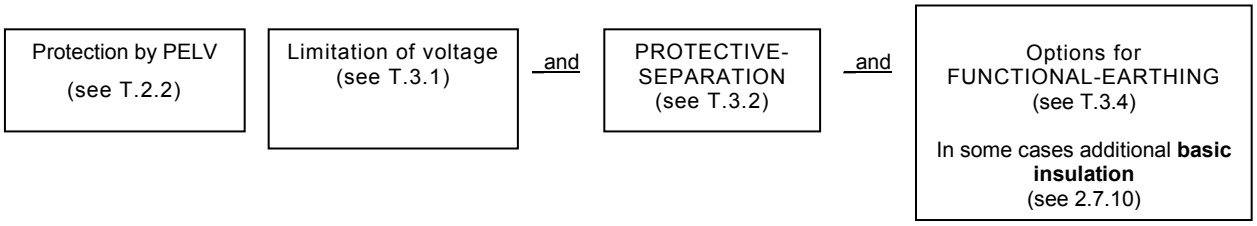
Requirements for SELV and PELV

T.1 Overview of the requirements for SELV and PELV

T.1.1 Protection by SELV



T.1.2 Protection by PELV



(Adopted from IEC 61140)

NOTE The requirements of IEC 61140 for barriers were considered and included in the requirements of this standard including, but not limited to, Clauses 8, 11, 18, and 20.

T.2 Protection against electric shock by SELV or PELV

T.2.1 SELV

Protection against electric shock shall be provided by the following measures:

– limitation of voltage **ELV,** according to T.3.1 in a circuit (the **SELV**-**system**), and

– protective-separation, according to T.3.2, of the **SELV**-**system** from all circuits other than **SELV** and PELV, and

– simple-separation, according to T.3.3, of the **SELV system** from other **SELV systems**, from **PELV systems** and from earth.

Intentional connection of **exposed-conductive-parts** of the **control** to a **protective conductor** or to an earth-conductor is not permitted.

In special locations where **SELV** is required and where protective screening according to T.3.2.1 is applied, the protective screen shall be separated from each adjacent circuit by **basic insulation** rated for the highest voltage present.

Requirements for the elements of **SELV** are given in Clause T.3.

T.2.2 PELV

Protection against electric shock shall be provided by the following measures:

– limitation of voltage, **ELV** according to T.3.1 in a circuit which may be earthed and/or the **exposed-conductive-parts** of which may be earthed (the **PELV system**), and

– **protective separation** according to T.3.2 of the **PELV system** from all circuits other than **SELV** and PELV.

If the **PELV** circuit is earthed and if protective screening according to T.3.2.1 is used, it is not necessary to provide **basic insulation** between the protective screen and the **PELV system**.

Where **live parts** of the **PELV system** are accessible (touchable) simultaneously with conductive parts which, in case of a **fault**, could assume the potential of the primary circuit, protection against electric shock depends on **protective-equipotential-bonding** (T.3.4) of all such conductive parts. Such parts shall be bonded to the protective earthing terminal or **termination** of the **control**.

Requirements for the elements of PELV are given in Clause T.3.

T.3 ELV, protective separation, simple separation, protective bonding as elements of SELV and PELV

T.3.1 Limitation of voltage shall provide that the voltage between simultaneously **accessible parts** does not exceed relevant **ELV** limits as specified in 2.1.4 and as specified in 8.1.1.

T.3.2 **Protective separation** between a **SELV**/PELV-circuit and other live circuits shall be achieved by means of:

– **basic insulation** and **supplementary insulation**, each rated for the highest voltage present, i.e. **double insulation**, or

– **reinforced insulation** rated for the highest voltage present, or

– protective screening according to T.3.2.1 with the protective screen being separated from each adjacent circuit by **basic insulation** rated for the highest adjacent circuit voltage (see also T.2.1, last paragraph), or

– a combination of these provisions.

If conductors of the separated circuit are contained together with conductors of other circuits in a multiconductor cable or in another grouping of conductors, they shall be insulated, individually or collectively, for the highest voltage present, so that **double insulation** or **reinforced insulation** is achieved.

If any component is connected between the separated circuits, that component shall comply with the requirements for **protective impedance**.

When the supply of **SELV** or PELV circuits is obtained from supply mains of higher voltages, it shall

– either be through a **safety isolating transformer**, or

– a converter with separate windings providing equivalent insulation and with requirements as below.

NOTE 1 The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at the upper limit of its rated voltage.

〚C〛 *Text deleted* 〚C〛

If a converter is used, and the **control** is declared

– IPX7 per 6.5.2, the **control** shall be declared to be subjected to second **fault** analysis (requirement 73 of Table 1) for the circuits and insulation between windings of the converter and as result of second **fault** the **ELV** value of 0 V shall not be exceeded. The current between the poles of the output shall comply with H.8.1.10.

Compliance is checked by inspection, measurement and when performing the appropriate test(s) in the order of this standard.

T.3.2.1 Protective screening shall consist of a **conductive screen** interposed between **hazardous live parts** of the **control**, installation, or **system** and the part being protected (for example, a **SELV**-circuit or a PELV circuit). The protective screen:

– shall be permanently and reliably connected to the protective earthing terminal of the **control** and the connection shall comply with the requirements of Clause 9; and

– shall itself comply with the requirements of Clause 9.

T.3.3 Simple-separation between a **SELV**-circuit and other **SELV systems** or **PELV systems** or earth shall comply with the requirements for **basic insulation** throughout, rated for the highest voltage present.

If any component is connected between the separated circuits, that component shall withstand the electric stresses specified for the insulation which it bridges and its impedance shall limit the prospective current flow through the component to the **steady-state current** values indicated in H.8.1.10 and H.11.2.5 for **protective impedance**.

T.3.4 Protective bonding

The requirements for protective bonding are those for protective earthing in Clause 9 of this standard.

For the installation of **controls** which consist of several component parts (sensing component, transmitters, central **control** unit, receivers, actors, interface units) and where such component parts are parts of the fixed electrical installation of a building, the requirements for protective bonding in IEC standards for installation of buildings apply.

NOTE Functional earthing is the connection of an electrical working circuit to earth for functional purposes as opposed to protective earthing. Depending on the type of installation system, different requirements apply and are given in the IEC standards for the installation of buildings. Functional earthing may be necessary for telecommunication equipment, for which IEC product standards apply.

*This standard allows the use of **exposed-conductive-parts** as **internal conductors** of an internal PELV circuit for functional earthing under conditions specified in this Part 1 and for particular applications in the relevant part 2.*

Annex U
(normative)

Requirements for relays when used as controls in IEC 60335 appliances

Annex U supplements or modifies the corresponding clauses of this standard.

NOTE These requirements were originally contained in IEC 60730-2-1 which has been withdrawn.[6]

U.2 Terms and definitions

U.2.2 Definitions of types of control according to purpose

U.2.2.12
electrically operated control
for the purpose of this annex, a relay is a **control** as defined in 2.2.12.

Replace the first note to entry with the following new note to entry:

NOTE An example is a relay, a current-operated relay, a voltage-operated relay, or a cycling replay.

U.4 General notes on tests

U.4.3 Instructions for test

U.4.3.5 According to purpose

Additional subclause:

U.4.3.5.4 *If a relay incorporates a ventilation means, this should be broken out for the tests of Clauses 12 to 17, if so declared*.

U.6 Classification

U.6.3 According to their purpose

Additional subclauses:

U.6.3.10.1 – relay

U.6.3.10.2 – current operated relay

U.6.3.10.3 – voltage operated relay

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6 IEC 60730-2-1:1989, *Automatic electrical controls for household and similar use – Part 2: Particular requirements for electrical controls for household appliances*

U.6.6 According to method of connection

Additional subclauses:

U.6.6.6 – **control** for printed wiring board mounting

U.6.6.7 – **control** for printed wiring board mounting, contact connections via other than printed wiring board tracks

U.6.6.8 – plug-in relay

U.6.8 According to protection against electric shock

Additional subclauses:

U.6.8.5 For a relay: insulation between coil and contact circuits:

U.6.8.5.1 – of class 0;

U.6.8.5.2 – of class 0I;

U.6.8.5.3 – of class I;

U.6.8.5.4 – of class II;

U.6.8.5.5 – of class III.

U.6.8.6 For a relay: insulation between **live parts** and test function, **manual action actuating member**:

U.6.8.6.1 – of class 0;

U.6.8.6.2 – of class 0I;

U.6.8.6.3 – of class I;

U.6.8.6.4 – of class II;

U.6.8.6.5 – of class III.

U.7 Information

Replace rows 3, 4 and 88 of Table 1 as follows:

Information	Clause or subclause	Method
3 Rated voltage for both coil and contacts, if different	U.14, U.17	C
4 Nature of supply for both coil and contacts, if different	U.14, U.17	C
88 Maximum intended click rate	U.23	D

U.14 Heating

Replacement of subclause:

U.14.4 *Tests shall be conducted under the following conditions:*

– *Coil voltage × 0,9 + contacts loaded or coil current × 0,9 + contacts loaded*

– *Coil voltage × 1,1 + contacts loaded or coil current × 1,1 + contacts loaded*

– *Coil de-energised + contacts loaded (N.C. contacts).*

– *Relays shall be mounted as specified – printed wiring board connected relays shall be mounted to a printed wiring board if submitted with relays to be tested. If not available, relays shall be mounted to plain printed wiring board material, conductors of the appropriate size (according to Table 6) shall be soldered to printed wiring board pins.*

U.17 Endurance

U.17.14 Evaluation of compliance

Replace the second list item as follows:

– *the requirements of Clause 14, under the conditions stated by U.14.4, with regard to those items designated by Table 13, footnote a, that is, terminals, current carrying parts, and supporting surfaces are met.*

U.17.16 Test for particular purpose controls

Relays shall be endurance tested according to the following schedule:

– *Ageing test of 17.6 if applicable*
– *Over-voltage test of **automatic action** of 17.7*
– *Test of **automatic action** at accelerated rate of 17.8*
– *Test of **automatic action** at slow rate of 17.9 if applicable*
– *Overvoltage test of **manual action** at accelerated speed of 17.10 if applicable*
– *Test of **manual action** at slow speed of 17.11 if applicable*
– *Test of **manual action** at high speed of 17.12 if applicable*
– *Test of **manual action** at accelerated speed of 17.13 if applicable*

U.20 Creepage distances, clearances and distances through solid insulation

Assessment shall be conducted with relay energised, de-energised, and manually operated (if applicable).

U.23 Electromagnetic compatibility (EMC) requirements – Emission

Consideration should be given as to whether EMC requirements are applicable to relays.

U.24 Components

Relays incorporating electronic components shall be assessed according to Annex H.

Annex V
(normative)

Requirements for controls powered by secondary batteries (rechargeable)

The following modifications to this standard are applicable for **controls** powered by batteries that can be recharged in the **control**.

V.4.3.2 According to rating

Additional subclauses:

V.4.3.2.11 **Operation** of the **control** is under the following conditions:

– the **control**, supplied by its fully charged battery, is operated as specified in this standard or the relevant part 2;

– the battery is charged, the battery being initially discharged to such an extent that the **control** cannot operate;

– if possible, the **control** is supplied from the supply mains through its battery charger, the battery being initially discharged to such an extent that the **control** cannot operate. The **control** is operated as specified in the relevant part 2;

– if the **control** incorporates inductive coupling between two parts that are detachable from each other, the **control** is supplied from the supply mains with the **detachable part** removed.

V.7 Information

Additional subclauses:

V.7.4 Additional requirements for marking

V.7.4.10 The instructions shall give information regarding charging of batteries.

V.8 Protection against electric shock

Additional subclauses:

V.8.5 Battery operated **controls** shall be so designed that at a **user** accessible external point of disconnection of a d.c. mains supply,

– the maximum accessible voltage is less than or equal to the limits of a **SELV**/PELV circuit.(for example, due to stored charge on a battery in the **control** or a redundant d.c. mains supply for backup), and

– the available power is less than 15 W at the end of 5 s.

V.8.5.1 *Verification is checked by the following test:*

*A test is conducted with the d.c. mains supply disconnected from a fully charged battery **control**. The voltage between the mains supply terminals is measured 1 s after disconnection of the mains supply. Then, a variable resistive load is connected to the input terminals where the d.c. mains supply is normally connected. The **control** is operated from its internal battery. The variable load is adjusted so that it draws maximum power through the circuit. The maximum power is recorded at the end of 5 s.*

If the voltage and the power recorded are within the limits specified in V.8.5, the circuit is deemed to meet the intent of V.8.5.

V.11.13.4.4.3 *The battery used for the following tests is a fully charged rechargeable battery as provided with, or recommended by the manufacturer for use with, the equipment.*

V.11.13.4.4.3.1 *Overcharging of a rechargeable battery. The battery is charged under each of the following conditions in turn.*

V.11.13.4.4.3.1.1 *The battery charging circuit is adjusted with the battery disconnected to give 106 % of the rated output voltage of the charger, or the maximum charging voltage available from the charger (without simulation of* ***faults****), whichever is the higher attainable value. The battery is then charged for 7 h.*

V. 11.13.4.4.3.1.2 *The battery charging circuit is adjusted, with the battery disconnected, to 100 % of the rated output voltage of the charger. The battery is charged while briefly subjected to the simulation of any single component* ***failure*** *that is likely to occur in the charging circuit and that results in overcharging of the battery. To minimize testing time, the* ***failure*** *is chosen that causes the highest overcharging current. The battery is then charged for a single period of 7 h with that simulated* ***failure*** *in place.*

V.11.13.4.4.3.2 *Reverse charging of a rechargeable battery. The battery is reverse charged while briefly subjected to the simulation of any single component* ***failure*** *that is likely to occur in the charging circuit and that would result in reverse charging of the battery. To minimize testing time, the* ***failure*** *is chosen that causes the highest reverse charging current. The battery is then reverse charged for a single period of 7 h with that simulated* ***failure*** *in place.*

V.11.13.4.4.3.3 *Excessive discharging rate for battery. The battery is subjected to rapid discharge by open-circuiting or short-circuiting any current-limiting or voltage-limiting components in the load circuit of the battery under test.*

V.11.13.4.4.3.4 *Compliance is in accordance with 11.13.4.4.4 and 11.13.4.5.*

Bibliography

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org/)

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60335 (all parts), *Household and similar electrical appliances – Safety*

IEC 60990:1999, *Methods of measurement of touch current and protective conductor current*

IEC 60243-1:1998, *Electrical strength of insulating materials – Test Methods – Part 1: Tests of power frequencies*

〔C〉 *Text deleted* 〈C〉

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General Requirements*

IEC 60998-2-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-1: Particular requirements for connecting devices as separate entities with screw-type clamping units*

〔C〉 EN 61000-4-20:2010, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides* (IEC 61000-4-20:2010)

EN 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments* (IEC 61000-6-1)

EN 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments* (IEC 61000-6-2) 〈C〉

IEC 61140:2001, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61508-3:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 3: Software requirements*

IEC 61508-7:2010, *Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 7: Overview of techniques and measures*

IEC 61810-1:2008, *Electromechanical elementary relays – Part 1: General requirements*

〔A1〕 ISO/IEC 9796 (all parts), *Information technology – Security techniques – Digital signature scheme giving message recovery*

ISO/IEC 9797 (all parts), *Information technology – Security techniques – Message Authentication Codes (MACs)*

ISO/IEC 9798 (all parts), *Information technology – Security techniques – Entity authentication* 〈A1〉

〈A1〉 ISO/IEC 10118 (all parts), *Information technology – Security techniques – Hash-functions*

ISO/IEC 11770 (all parts), *Information technology – Security techniques – Key Management*

ISO/IEC 14888 (all parts), *Information technology – Security techniques – Digital signatures with appendix*

ISO/IEC 15946 (all parts), *Information technology – Security techniques – Cryptographic techniques based on elliptic curves*

ISO/IEC 18033 (all parts), *Information technology – Security techniques – Encryption algorithms*

ISO/IEC 19772 (all parts), *Information technology – Security techniques – Authenticated encryption*

ISO/IEC 29192 (all parts), *Information technology – Security techniques – Lightweight cryptography* 〈A1〉

ISO/IEC Guide 51:1999, *Safety aspects – Guidelines for their inclusion in standards*

ISO 62:2008, *Plastics – Determination of water absorption*

ISO 75-1:2004, *Plastics – Determination of temperature of deflection under load – Part 1: General test method*

ISO 178:2010, *Plastics – Determination of flexural properties*

ISO 180:2000, *Plastics – Determination of Izod impact strength*

ISO 527-1:2012, *Plastics – Determination of tensile properties – Part 1: General principles*

〈C〉 ISO 4046:1978 [1)], *Paper, board, pulp and related terms – Vocabulary* 〈C〉

ISO 8256:2004, *Plastics – Determination of tensile-impact strength*

ISO 16484 (all parts), *Building automation and control systems (BACS)*

EN 50159, *Railway applications – Communication, signalling and processing systems – Safety-related communication in transmission systems*

UL 746C, *Polymeric Materials – Use in Electrical Equipment Evaluations*

HOLSCHER, H. and RADER, J; "Microcomputers in safety techniques." Verlag TUV Bayern. TUV Rheinland. (ISBN 3-88585-315-9).

ABRAHAM, J.A.; THATTE, S.M.; "Fault coverage of test programs for a microprocessor", Proceedings of the IEEE Test Conference 1979, pp 18-22.

IECQ programme http://www.iecq.org

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〈C〉 1) ISO 4046:1978 is replaced by ISO 4046-1:2002, *Paper, board, pulps and related terms – Vocabulary – Part 1: Alphabetical index*. 〈C〉

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