

INTERNATIONAL STANDARD

**Explosive atmospheres –
Part 7: Equipment protection by increased safety "e"**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2015 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.



IEC 60079-7

Edition 5.0 2015-06

INTERNATIONAL STANDARD

**Explosive atmospheres –
Part 7: Equipment protection by increased safety "e"**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.260.20

ISBN 978-2-8322-2710-7

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	8
1 Scope.....	14
2 Normative references	15
3 Terms and definitions	17
4 Constructional requirements	21
4.1 Level of Protection	21
4.2 Electrical connections	21
4.2.1 General	21
4.2.2 Field wiring connections	22
4.2.3 Factory connections.....	23
4.2.4 External plug and socket connections for field wiring connection	25
4.3 Clearances	26
4.4 Creepage distances	26
4.5 Printed wiring boards with conformal coating, Level of Protection “ec”	32
4.6 Solid electrical insulating materials	33
4.6.1 Specification.....	33
4.6.2 Long-term thermal stability	33
4.7 Windings.....	34
4.7.1 General	34
4.7.2 Insulated conductors	34
4.7.3 Winding impregnation	34
4.7.4 Conductor dimensions	34
4.7.5 Sensing elements	35
4.8 Temperature limitations	35
4.8.1 General	35
4.8.2 Conductors	35
4.8.3 Insulated windings	36
4.9 Wiring internal to equipment	36
4.10 Degrees of protection provided by enclosures.....	37
4.11 Fasteners	38
5 Supplementary requirements for specific electrical equipment	38
5.1 General.....	38
5.2 Electrical machines	38
5.2.1 General	38
5.2.2 Degrees of protection provided by electrical machines, Level of Protection “eb”	39
5.2.3 Degrees of protection provided by electrical machines, Level of Protection “ec”	39
5.2.4 Connection facilities for external conductors	39
5.2.5 Internal fans	39
5.2.6 Minimum air gap	39
5.2.7 Rotating electrical machines with cage rotors	40
5.2.8 Limiting temperature	42
5.2.9 Machines with permanent magnet rotors	45
5.2.10 Stator winding insulation system	45
5.2.11 Supplemental winding requirements Level of Protection “eb”	46

5.2.12	Bearing seals and shaft seals	46
5.2.13	Neutral point connections	47
5.3	Luminaires, hand lights, or caplights	47
5.3.1	General	47
5.3.2	Light source	48
5.3.3	Minimum distance between lamp and protective cover	49
5.3.4	Electrical spacings	49
5.3.5	Lampholders and lamp caps	50
5.3.6	Auxiliaries for Luminaires in Level of Protection “ec”	53
5.3.7	Surface temperatures	54
5.3.8	Limiting temperatures	55
5.3.9	Luminaires for tubular fluorescent bi-pin lamps	55
5.3.10	Tests for resistance to impact	56
5.4	Analog measuring instruments and instrument transformers	56
5.4.1	General	56
5.4.2	Limiting temperature	56
5.4.3	Short-circuit currents	56
5.4.4	Short time thermal current	57
5.4.5	Measuring instruments supplied by current transformers	57
5.4.6	Moving coils	57
5.4.7	External secondary circuits	57
5.5	Transformers other than instrument transformers	57
5.6	Supplementary requirements for equipment incorporating cells and batteries	58
5.6.1	Type of cells and batteries	58
5.6.2	Requirements for cells and batteries ≤ 25 Ah	59
5.6.3	Requirements for valve-regulated or vented cells or batteries > 25 Ah	62
5.6.4	Charging of cells and batteries	65
5.7	General purpose connection and junction boxes	66
5.8	Resistance heating equipment (other than trace heating systems)	66
5.8.1	General	66
5.8.2	Heating resistors	66
5.8.3	Temperature coefficient	67
5.8.4	Insulating material	67
5.8.5	Cold-start current	67
5.8.6	Electrical safety device	67
5.8.7	Electrically conductive covering	67
5.8.8	Exclusion of explosive atmosphere	68
5.8.9	Conductor cross-section	68
5.8.10	Limiting temperature	68
5.8.11	Safety device	68
5.9	Supplementary requirements for fuses	69
5.9.1	General	69
5.9.2	Temperature class of equipment	70
5.9.3	Fuse mounting	70
5.9.4	Fuse enclosures	70
5.9.5	Replacement fuse identification	70
5.10	Other electrical equipment	70
6	Type verifications and type tests	70
6.1	Dielectric strength	70

6.2	Rotating electrical machines	71
6.2.1	Determination of starting current ratio I_A/I_N and the time t_E	71
6.2.2	Mounting of machine for test.....	71
6.2.3	Additional tests for machines	71
6.2.4	Overspeed test of cemented magnets	73
6.3	Luminaires	73
6.3.1	Battery operated luminaires	73
6.3.2	Impact and drop tests	73
6.3.3	Mechanical tests for screw lampholders other than E10.....	74
6.3.4	Abnormal operation of luminaires	75
6.3.5	Sulphur dioxide test for Level of Protection “eb” for the connection of bi-pin lamp caps to lampholders	76
6.3.6	Vibration test for Level of Protection “eb” for luminaires with bi-pin lamps	77
6.3.7	Test for wiring of luminaires subject to high-voltage impulses from ignitors	78
6.3.8	Tests for electronic starters for tubular fluorescent lamps and for ignitors in Level of Protection “ec” for discharge lamps	78
6.3.9	Test for starter holders for luminaires in Level of Protection “ec”	79
6.4	Measuring instruments and instrument transformers	79
6.5	Transformers other than instrument transformers.....	80
6.6	Verification and tests for cells and batteries of Level of Protection “eb”	80
6.6.1	General	80
6.6.2	Insulation resistance.....	80
6.6.3	Mechanical shock test	80
6.6.4	Test for ventilation of Level of Protection “eb” battery container.....	81
6.7	Verification and tests for cells and batteries of Level of Protection “ec”	82
6.7.1	General	82
6.7.2	Insulation resistance.....	82
6.7.3	Mechanical shock test	82
6.7.4	Test for ventilation of Level of Protection “ec” battery container.....	82
6.8	General purpose connection and junction boxes	83
6.8.1	General	83
6.8.2	Maximum dissipated power method	83
6.8.3	Defined arrangement method.....	83
6.9	Resistance heating equipment	83
6.10	Terminal insulating material tests.....	84
7	Routine verifications and routine tests	85
7.1	Dielectric tests	85
7.2	Dielectric tests for batteries	86
7.3	Inter-turn overvoltage tests	86
8	Ex Component certificates	86
8.1	General.....	86
8.2	Terminals.....	86
9	Marking and instructions.....	87
9.1	General marking	87
9.2	Ex Component enclosures	88
9.3	Instructions for use	88
9.3.1	Battery operated equipment.....	88

9.3.2	Terminals	88
9.3.3	Luminaires.....	88
9.3.4	Machines	89
9.4	Warning markings	89
10	Documentation	90
Annex A (normative) Temperature determination of electrical machines – Methods of test and of calculation.....		91
A.1	General.....	91
A.2	Determination of maximum service temperatures	91
A.2.1	Rotor temperature – normal operation	91
A.2.2	Winding temperature – normal operation	91
A.3	Determination of maximum surface temperatures.....	92
A.3.1	General	92
A.3.2	Locked rotor tests	92
A.4	Optional calculation of maximum surface temperature	93
A.4.1	General	93
A.4.2	Rotor temperature	93
A.4.3	Stator temperature.....	93
A.5	Determination of t_E time	93
A.6	Arduous starting conditions.....	94
A.7	Motors operated with a converter	94
Annex B (normative) Type tests for specific forms of resistance heating devices or resistance heating units (other than trace heater)		95
B.1	Resistance heating devices subjected to mechanical stresses	95
B.2	Resistance heating devices or units intended for immersion.....	95
B.3	Resistance heating devices or units having hygroscopic insulating material.....	95
B.4	Verification of limiting temperature of resistance heating devices (other than trace heaters)	95
B.4.1	General	95
B.4.2	Safety devices	95
B.4.3	Resistance heating unit of stabilized design.....	96
B.4.4	Heating device with temperature self-limiting characteristic	96
Annex C (informative) Cage motors – Thermal protection in service.....		97
Annex D (informative) Resistance heating devices and units – Additional electrical protection		98
D.1	Objective	98
D.2	Method of protection	98
Annex E (informative) Combinations of terminals and conductors for general purpose connection and junction boxes.....		99
E.1	General.....	99
E.2	Maximum dissipated power method.....	99
E.3	Defined arrangement method	99
Annex F (normative) Dimensions of copper conductors.....		102
Annex G (normative) Test procedure for T5 (only 8 W), T8, T10 and T12 lamps.....		103
G.1	Asymmetric pulse test.....	103
G.1.1	General	103
G.1.2	Test procedure	103
G.2	Asymmetric power test.....	104
G.2.1	General	104

G.2.2	Test procedure	105
Annex H (normative) Alternative separation distances for Level of Protection “ec” equipment under controlled environments..... 108		
H.1	General.....	108
H.2	Specific Conditions of Use	108
H.3	Control of pollution access	109
H.4	Voltage limitation	109
H.5	Control of overvoltages and transient protection	109
H.6	Alternative separation distances	109
Annex I (informative) Application, installation, and testing considerations for Level of Protection “ec” asynchronous machines..... 111		
I.1	Surface temperature	111
I.2	Starting.....	111
I.3	Rated voltage and surface discharges	112
Annex J (informative) Luminaires incorporating LEDs		
J.1	LEDs for EPL Gb	113
J.2	LEDs for EPL Gc.....	113
Bibliography..... 114		
Figure 1 – Determination of creepage distances and clearances..... 32		
Figure 2 – Minimum values of the time t_E (in seconds) of motors in relation to the starting current ratio I_A/I_N		
Figure 3 – Arrangement for the luminaire vibration test..... 77		
Figure A.1 – Diagram illustrating the determination of time t_E		
Figure E.1 – Example of defined terminal/conductor arrangement table		
Figure G.1 – Asymmetric pulse test circuit		
Figure G.2 – Asymmetric power detection circuit..... 106		
Figure G.3 – Flow Chart – Asymmetric power Test for T8, T10, T12 and T5 (8 W lamps)		
Table 1 – Tracking resistance of insulating materials		
Table 2 – Minimum Creepage distances, clearances and separations		
Table 3 – Conditions for the determination of maximum surface temperature..... 35		
Table 4 – Maximum temperatures for insulated windings		
Table 5 – Potential air gap sparking risk assessment for cage rotor ignition risk factors..... 42		
Table 6 – Stator insulation system tests of Level of Protection “ec” machines		
Table 7 – Assumed voltage of neutral points..... 47		
Table 8 – Minimum distance between lamp and protective cover		
Table 9 – Creepage distances and clearances at peak values of pulse voltages greater than 1,5 kV		
Table 10 – Creepage distances and clearances for screw lampholder and lamp cap..... 51		
Table 11 – Resistance to the effect of short-circuit currents		
Table 12 – Types and use of cells and batteries		
Table 13 – Explosion test mixtures		
Table 14 – Tests for resistance to impact..... 74		
Table 15 – Insertion torque and minimum removal torque		

Table 16 – Power dissipation of cathodes of lamps supplied by electronic ballasts	76
Table 17 – Value for pull-out tests	85
Table 18 – Creepage distances and clearances for screw lamp caps	89
Table 19 – Text of warning markings.....	89
Table F.1 – Standard cross-sections of copper conductors	102
Table H.1 – Alternative separation distances for equipment under controlled environments	110

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –**Part 7: Equipment protection
by increased safety "e"****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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 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.

International Standard IEC 60079-7 has been prepared by IEC Technical Committee 31: Equipment for explosive atmospheres.

This fifth edition cancels and replaces the fourth edition published in 2006, and constitutes a technical revision.

The requirements for Type of Protection "nA" have been relocated from IEC 60079-15. To assist the user of this document, the significant changes with respect to the previous edition are shown below in two separate tables, one showing the changes from IEC 60079-7, Edition 4 (2006) for "e" to IEC 60079-7, Edition 5 (2014) for "eb"; and the other showing the changes from IEC 60079-15, Edition 4 (2010) for "nA" to IEC 60079-7, Edition 5 (2014) for "ec".

The significance of the changes between IEC Standard, IEC 60079-7, Edition 5 (2014) (for “eb”) and IEC 60079-7, Edition 4 (2006) (for “e”) are as listed below:

for “e” to “eb”		Type		
Explanation of the significance of the changes	Clause	Minor and editorial changes	Extension	Major technical changes
Scope Clarification of applicability Notes added to address short circuits and short-term thermal excursions	1	X		
Clarification of resistance heating definitions	3.13	X		
Addition of terminal insulation material tests	4.2.2.4			C1
Soldered Connections	4.2.2.5 4.2.3.3			C2
Silver-Soldered connections	4.2.3.3	X		
Clarification of “duplicated” contacts	4.2.3.4a)	X		
External plug and socket connections for field wiring connection of batteries	4.2.4	X		
Clarification of conditions for the determination of maximum surface temperature	4.8.1 Table 3	X		
Maximum temperatures for insulated windings	Table 4	X		
Degrees of protection provided by enclosures	4.10.1		x	C3
Clarification of applicability	5.2.1	X		
Minimum air gap for motors	5.2.6	X		
Devices for limiting winding temperature protection	5.2.8.2 5.2.8.3		X	
Permanent magnet motors	5.2.9 6.2.4 9.3.4c)		X	
Added Tungsten-Halogen lamp	5.3.2.2 5.3.2.3 5.3.2.4		X	
Added spacings for < 10 W lamps	5.3.3		X	
Permission added for re-lamping outside of hazardous area	5.3.5.2.2		X	
Added bayonet lamps	5.3.5.4.2		X	
Added contact requirements for bayonet lamps	5.3.5.5		X	
Renaming of “Type” of cells and batteries	5.6.2	X		
Clarification of approaches for general purpose junctions boxes	5.7 6.9 Annex E	X		
Clarified temperature monitoring and control	5.8	X		
Clarification of testing of battery powered luminaires	6.3.1	X		
Clarification of impact tests	6.3.2.2	X		
Added abnormal tests for discharge lamps	6.3.4.1			C4
Added T5 8W	6.3.4.3 Table 16		X	

for “e” to “eb”		Type		
Explanation of the significance of the changes	Clause	Minor and editorial changes	Extension	Major technical changes
To maintain T4 temperature class, cathode power or ambient temperature reduced	6.3.4.3 Table 16			C5
Clarification of routine tests for terminal boxes	7.1	X		
Marking of “e” replaced by “eb”	9.1	See “Information about the background of Changes”		
Ex Component enclosures	9.2			C6
Highlight essential documentation for rotating electrical machines	10	X		
Temperature tests	Annex A		X	

The significance of the changes between IEC Standard, IEC 60079-7, Edition 5 (2015) (for “ec”) and IEC 60079-15, Edition 4 (2010) (for “nA”) are as listed below:

for “nA” to “ec”		Type		
Explanation of the significance of the changes	Clause	Minor and editorial changes	Extension	Major technical changes
Scope Clarification of applicability Notes added to address short circuits and short-term thermal excursions	1	X		
Clarification of resistance heating definitions	3.13	X		
Soldered Connections	4.2.2.5 4.2.3.3			C7
Silver-Soldered connections	4.2.3.3	X		
Evaluation of pluggable connections	4.2.3.5a)	X		
External plug and socket connections for field wiring connection	4.2.4	X		
Minimum separation distances for encapsulated or solid insulation replaced by requirements for solid insulating materials	4.3 4.4 4.5 Table 2	X		
Alternative separation distances for equipment under controlled environments	4.3 4.4 Annex H		X	
Thermal stability of solid insulating materials	4.6			C8
Clarification of conditions for the determination of maximum surface temperature	4.8.1 Table 3	X		
Maximum temperatures for insulated windings	Table 4	X		
Clarification of applicability	5.2.1	X		
Permanent magnet motors	5.2.9 6.2.4 9.3.4c)		X	
Clarified applicability to handlights and caplights	5.3	X		

for “nA” to “ec”		Type		
Explanation of the significance of the changes	Clause	Minor and editorial changes	Extension	Major technical changes
Addition of permitted light sources	5.3.2 Annex J		X	
Added spacings for < 10 W & 100-200 W lamps	5.3.4		X	
Added LED as a light source	5.3.2.5 0		X	
Clarified internal spacings for LED packages	0	X		
Added spacings for < 10 V lamps	5.3.5.3.2		X	
Clarification of temperature testing	5.3.7	X		
Renaming of “Type” of cells and batteries	5.6.1	X		
Clarification of approaches for general purpose junctions boxes	5.7 6.8 Annex E	X		
Clarified temperature monitoring and control	5.8	X		
Clarification of permitted fuses	5.9.1	X		
Clarification of testing of battery powered luminaires	6.3.1	X		
Addition of end-of-life tests	6.3.4.3.2 Table 16			C9
Dielectric tests based on industrial standards	7.1		X	
Clarification of routine tests for terminal boxes	7.1	X		
Marking of “nA” is replaced by “ec”	9.1	See “Information about the background of Changes”		
Ex Component enclosures	9.2			C10
Highlight essential documentation for rotating electrical machines	10	X		
Temperature tests	Annex A		X	
Alternative separation distances	Annex H	A1		

NOTE The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version.

Explanations:

A) Definitions

Minor and editorial changes

clarification
decrease of technical requirements
minor technical change
editorial corrections

These are changes which modify requirements in an editorial or a minor technical way. They include changes of the wording to clarify technical requirements without any technical change, or a reduction in level of existing requirement.

Extension

addition of technical options

These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing requirements for equipment that was fully

compliant with the previous standard. Therefore, these will not have to be considered for products in conformity with the preceding edition.

Major technical changes

addition of technical requirements
increase of technical requirements

These are changes to technical requirements (addition, increase of the level or removal) made in a way that a product in conformity with the preceding edition will not always be able to fulfil the requirements given in the later edition. These changes have to be considered for products in conformity with the preceding edition. For these changes additional information is provided in clause B) below.

NOTE These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

B) Information about the background of 'Changes

Marking:

Former marking of "nA" has been replaced by marking "ec". Even if the other technical aspects on the product are unchanged and comply with the revised requirements, a change in the marking will be required.

Former marking of "e" has been replaced by marking "eb". Even if the other technical aspects on the product are unchanged and comply with the revised requirements, a change in the marking will be required.

- A1 The text of Annex H for *Alternative separation distances for Level of Protection "ec" equipment under controlled environments* has been reorganized and clarified from Clause 13 of IEC 60079-15, Ed 4; to facilitate consistent application of the requirements. The title has been revised to remove "low power" as power is not relevant for insulation coordination in accordance with IEC 60664-1. Although a clarification, it is recognized that some existing equipment may not meet the clarified requirement.
- C1 The terminal insulating materials are now subjected to the same tests as rail-mounted terminals as a failure of the material presents the same hazard.
- C2 Although a clarification, it is recognized that some existing equipment will not meet the clarified requirement. The requirements for soldered connections were revised to specify that mechanical support of the connection was required in addition to the solder. It is not a requirement that the connection function electrically in the absence of the solder.
- C3 Ingress protection requirements for Group I increased from IP20 to IP23 for consistency with the remainder of the document.
- C4 Added abnormal tests for discharge lamps.
- C5 Based on further research, maintaining temperature class T4, under conditions of end-of-life, requires either the cathode power or the ambient temperature be reduced.
- C6 Requirements for Ex Component "e" enclosures introduced based on those for Ex Component "d" enclosures. Even if the other technical aspects on the product are unchanged and comply with the revised requirements, a change in the marking will be required.
- C7 Although a clarification, it is recognized that some existing equipment may not meet the clarified requirement. The requirements for soldered connections were revised to specify that mechanical support of the connection was required in addition to the solder. It is not a requirement that the connection function electrically in the absence of the solder.
- C8 Requirements added for the use of solid insulating materials within the limits of their thermal stability.
- C9 Based on further research, requirements for T5 lamps added.

C10 Requirements for Ex Component “e” enclosures introduced based on those for Ex Component “d” enclosures. Even if the other technical aspects on the product are unchanged and comply with the revised requirements, a change in the marking will be required.

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

FDIS	Report on voting
31/1182/FDIS	31/1194/RVD

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

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

A list of all parts of IEC 60079 series, under the general title *Explosive atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC 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.

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

EXPLOSIVE ATMOSPHERES –

Part 7: Equipment protection by increased safety "e"

1 Scope

This part of IEC 60079 specifies the requirements for the design, construction, testing and marking of electrical equipment and Ex Components with type of protection increased safety "e" intended for use in explosive gas atmospheres.

Electrical equipment and Ex Components of type of protection increased safety "e" are either:

- a) Level of Protection "eb" (EPL "Mb" or "Gb"); or
- b) Level of Protection "ec" (EPL "Gc")

Level of Protection "eb" applies to equipment or Ex Components, including their connections, conductors, windings, lamps, and batteries; but not including semiconductors or electrolytic capacitors.

NOTE 1 The use of electronic components, such as semiconductors or electrolytic capacitors, is excluded from Level of Protection "eb" as expected malfunctions could result in excessive temperatures or arcs and sparks if the internal separation distances were not applied. It is not generally practical to maintain those separation distances and maintain the function of the electronic component.

Level of Protection "ec" applies to equipment or Ex Components, including their connections, conductors, windings, lamps, and batteries; and also including semiconductors and electrolytic capacitors.

NOTE 2 The use of electronic components, such as semiconductors or electrolytic capacitors, is permitted in Level of Protection "ec" as these are evaluated under both normal conditions and regular expected occurrences, and are not likely to result in excessive temperatures or arcs and sparks. As the requirements for separation distances are not applied to the internal construction, commercially available electronic components are generally suitable if the external separation distances comply.

The requirements of this standard apply to both Levels of Protection unless otherwise stated.

For Level of Protection "eb", this standard applies to electrical equipment where the rated voltage does not exceed 11 kV r.m.s., a.c. or d.c.

For Level of Protection "ec", this standard applies to electrical equipment where the rated voltage does not exceed 15 kV r.m.s., a.c. or d.c.

NOTE 3 Short circuit currents flowing through increased safety connections of mains circuits are not considered to create a significant risk of ignition of an explosive gas atmosphere due to movement of connections as a result of mechanical stresses created by the short circuit current. Normal industrial standards require that the effects of short time high currents on the security of connections be considered. The presence of the explosive gas atmosphere does not adversely affect the security of the connection.

NOTE 4 Any short term thermal excursions that occur as a result of electrical current excursions above normal rated currents, such as those that occur during the starting of motors, are not considered to create a significant risk of ignition of an explosive gas atmosphere due to the relatively short duration of the event and the convection that occurs during the event.

NOTE 5 High-voltage connections and associated wiring (above 1 kV) can be susceptible to increased partial discharge activity that could be a source of ignition. Increased spacings to earthed surfaces or other connections and provision of suitable high-voltage stress relief for the terminations are typically provided.

This standard supplements and modifies the general requirements of IEC 60079-0. Where a requirement of this standard conflicts with a requirement of IEC 60079-0, the requirement of this standard takes precedence.

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 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60044-6, *Instrument transformers – Part 6: Requirements for protective current transformers for transient performance*

IEC 60061-1, *Lamp caps and holders together with gauges for the control of interchangeability and safety. Part 1: Lamp caps*

IEC 60061-2, *Lamp caps and holders together with gauges for the control of interchangeability and safety – Part 2: Lampholders*

IEC 60064, *Tungsten filament lamps for domestic and similar general lighting purposes – Performance requirements*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-42, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

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

IEC 60112, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60216-1, *Electrical insulating materials – Thermal endurance properties – Part 1: Ageing procedures and evaluation of test results*

IEC 60216-2, *Electrical insulating materials – Thermal endurance properties – Part 2: Determination of thermal endurance properties of electrical insulating materials – Choice of test criteria*

IEC 60228, *Conductors of insulated cables*

IEC 60238, *Edison screw lampholders*

IEC 60317-3:2004, *Specifications for particular types of winding wires – Part 3: Polyester enamelled round copper wire, class 155*

IEC 60317-3:2004/AMD1:2010

IEC 60317-8, *Specifications for particular types of winding wires – Part 8: Polyesterimide enamelled round copper wire, class 180*

IEC 60317-13, *Specifications for particular types of winding wires – Part 13: Polyester or polyesterimide overcoated with polyamide-imide enamelled round copper wire, class 200*

IEC 60317-46, *Specifications for particular types of winding wires – Part 46: Aromatic polyimide enamelled round copper wire, class 240*

IEC 60400, *Lampholders for tubular fluorescent lamps and starterholders*

IEC 60432-1, *Incandescent lamps – Safety specifications – Part 1: Tungsten filament lamps for domestic and similar general lighting purposes*

IEC 60432-2, *Incandescent lamps – Safety specifications – Part 2: Tungsten halogen lamps for domestic and similar general lighting purposes*

IEC 60432-3, *Incandescent lamps – Safety specifications – Part 3: Tungsten halogen lamps (non-vehicle)*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60598-1, *Luminaires – Part 1: General requirements and tests*

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

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

IEC 60947-7-1, *Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors*

IEC 60947-7-2, *Low-voltage switchgear and controlgear – Part 7-2: Ancillary equipment – Protective conductor terminal blocks for copper conductors*

IEC 60947-7-4, *Low-voltage switchgear and controlgear – Part 7-4: Ancillary equipment – PCB terminal blocks for copper conductors*

IEC 60998-2-4, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-4: Particular requirements for twist-on connecting devices*

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)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm² up to 300 mm² (included)*

IEC 61184, *Bayonet lampholders*

IEC 61195, *Double-capped fluorescent lamps – Safety specifications*

IEC 61347-1, *Lamp controlgear – Part 1: General and safety requirements*

IEC 61347-2-3, *Lamp control gear – Part 2-3: Particular requirements for a.c. and/or d.c. supplied electronic control gear for fluorescent lamps*

IEC 62035, *Discharge lamps (excluding fluorescent lamps) – Safety specifications*

ISO 2859-1, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 527-2, *Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*

ISO 178, *Plastics – Determination of flexural properties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0, as well as the following apply.

NOTE For the definitions of any other terms, particularly those of a more general nature, please refer to IEC 60050-426 or other appropriate parts of IEC 60050, *International Electrotechnical Vocabulary*.

3.1

cell and battery types

3.1.1

sealed cell

cell which remains closed and does not release either gas or liquid when operated within the limits specified by the manufacturer

Note 1 to entry: A sealed cell is often equipped with a safety device to protect against a dangerously high internal pressure and is designed to operate during its life in its original sealed state.

Note 2 to entry: A sealed cell was formerly known as a Type 1 cell in IEC 60079-15.

3.1.2

valve-regulated cell or battery

secondary cell or battery which is closed under normal conditions but which has an arrangement which allows the escape of gas if the internal pressure exceeds a pre-determined value

Note 1 to entry: The cell cannot normally receive an addition to the electrolyte.

Note 2 to entry: A valve-regulated cell or battery was formerly known as a Type 2 cell in IEC 60079-15.

3.1.3

vented cell or battery

secondary cell or battery having a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely from the cell or battery to the atmosphere

Note 1 to entry: A vented cell or battery was formerly known as a Type 3 cell in IEC 60079-15.

3.2

duty type (motor)

continuous, short-time or periodic duty, comprising one or more loads remaining constant for the duration specified, or a non-periodic duty in which generally load and speed vary within the permissible operating range

Note 1 to entry: These include duty types S1 to S10, as defined in IEC 60034-1.

3.3

ferrule

metal tube crimped over stranded wire to secure it within a terminal usually with electrical insulation protecting any exposed portion of the wire not completely inside the terminal post

3.4

fuse

device that by the fusing of one or more of its specially designed and proportioned components intended to melt under the action of current exceeding some definite value for a definite period of time, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time

3.5

increased safety "e"

type of protection applied to electrical equipment or Ex Components in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and against the occurrence of arcs and sparks

3.6

initial starting current

I_A

highest r.m.s. value of current drawn by an a.c. motor when at rest or by an a.c. magnet with its armature clamped in the position of maximum air gap when supplied at rated voltage and rated frequency

Note 1 to entry: Transient phenomena are ignored.

3.7

Light Emitting Diode

LED

solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current

3.8

LED module

light source having no cap, incorporating one or more LED package(s) on a printed circuit board, and possibly including one or more of the following: electrical, optical, mechanical, and thermal components, interfaces, and controlgear

3.9

LED package

single electrical component encapsulating principally one or more LEDs, possibly with optical elements and thermal, mechanical, and electrical interfaces

Note 1 to entry: The component does not include the control unit of the controlgear, does not include a cap, and is not connected directly to the supply voltage.

Note 2 to entry: An LED package is a discrete component and part of the LED module or LED lamp.

3.10

normal service

<machines>continuous operation at the nameplate rating (or set of ratings) generally including starting conditions

Note 1 to entry: Normal service for Level of Protection “ec” motors of duty types S1 or S2 does not include starting.

3.11

rated dynamic current

I_{dyn}

peak value of the current, the dynamic effect of which the electrical equipment can sustain without damage

3.12

rated short-time thermal current

I_{th}

r.m.s. value of the current required to heat up the conductor within 1 s from the temperature reached in rated service at the maximum ambient temperature to a temperature not exceeding the limiting temperature

3.13

resistance-heating applications

3.13.1

resistance-heating

utilization of electric resistance-heating devices, units and any associated controls (other than electrical trace heating systems)

Note 1 to entry: Electric trace heating systems are addressed by IEC 60079-30-1.

3.13.2

resistance-heating device

part of a resistance heating unit consisting of one or more heating resistors, typically composed of metallic conductors or an electrically conductive material suitably insulated and protected

Note 1 to entry: An example of a resistance heating device covered by this standard is an anti-condensation heater.

3.13.3

resistance-heating unit

equipment consisting of an assembly of one or more resistance heating devices associated with any safety devices necessary to ensure that the limiting temperature is not exceeded

Note 1 to entry: It is not intended that the safety devices necessary to ensure that the limiting temperature is not exceeded should have Type of Protection “e” or any type of protection when they are located outside the hazardous area.

3.13.4

workpiece

object to which a resistance-heating device or resistance-heating unit is applied

3.13.5

temperature self-limiting characteristic

characteristic whereby the thermal output of a resistance-heating device at its rated voltage decreases as the temperature of its surroundings increases until the device reaches a temperature at which its thermal output is reduced to a value at which there is no further rise in temperature

Note 1 to entry: The temperature of the surface of the element is then effectively that of its surroundings.

3.13.6

stabilized design

design where the temperature of the resistance-heating device or resistance-heating unit will, by design and use, stabilize below the limiting temperature, under the most unfavourable conditions, without the need for a safety device to limit the temperature

3.14 **short-circuit current**

I_{sc}

maximum r.m.s. value of the short-circuit current to which the equipment may be subjected in service

Note 1 to entry: This maximum value is recorded in the documentation prepared according to IEC 60079-0.

3.15 **solid insulation**

electrical insulation material, which is extruded or moulded, but not poured

Note 1 to entry: Insulators fabricated from two or more pieces of electrical insulating material, which are solidly bonded together can be considered as solid. The term solid insulation describes the final form and not necessarily the form in which they are initially applied. For windings of electrical machines, the process of using varnish as a means of consolidating and insulating the winding is considered to result in solid insulation, irrespective of how the varnish is applied.

3.16 **starting current ratio**

I_A/I_N

ratio between initial starting current I_A and rated current I_N

3.17 **stator winding**

stationary winding in an electric machine, either for rotary or linear motion

3.18 **time**

t_E

time, in seconds, taken for an a.c. rotor or stator winding, when carrying the initial starting current I_A , to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature (see Figure A.1)

3.19 **trace heater**

device designed for the purpose of producing heat on the principle of electrical resistance and typically composed of one or more metallic conductors or an electrically conductive material suitably electrically insulated and protected

Note 1 to entry: For additional information on trace heaters, see IEC 60079-30-1.

3.20 **terminal**

point of interconnection of an electric circuit element, a circuit, or a network with other electric circuit elements, electric circuits or networks

3.21 **safety device**

device intended for use inside or outside explosive atmospheres but required for, or contributing to, the safe functioning of equipment and protective systems with respect to the risks of explosion

Note 1 to entry: TC31 has initiated a project to consider the development of an IEC standard based on EN 50495 which would provide requirements for these safety devices.

3.22 **transportable**

capable of being moved from one location to another, generally by using vehicles

4 Constructional requirements

4.1 Level of Protection

Electrical equipment with Type of Protection increased safety “e” shall be one of the following:

- Level of Protection “eb” (EPL “Mb” or “Gb”); or
- Level of Protection “ec” (EPL “Gc”).

The requirements of this clause apply, unless otherwise stated in Clause 5, to all electrical equipment and Ex Components with Type of Protection “e”.

4.2 Electrical connections

4.2.1 General

Electrical connections intended to be terminated internal to the equipment enclosures are subdivided into those for field-wiring, 4.2.2, and for factory wiring, 4.2.3, and into permanent types and reconnectable/rewireable types for convenience in detailing the appropriate requirements.

External earthing and equipotential bonding connections shall comply with the requirements for field wiring connections, 4.2.2.

Each type shall, as applicable:

- a) be constructed in such a way that the conductors cannot slip out from their intended location during tightening of a screw or after insertion;
- b) provide a means to avoid loosening of the connection in service;
- c) be such that contact is assured without damage to the conductors such that would impair the ability of the conductors to fulfil their function, even if multi-stranded conductors are used in connections intended for direct clamping of a single conductor;
- d) provide a positive compression force to assure contact pressure in service;
- e) be constructed in such a way that the contact they assure is not appreciably impaired by temperature changes occurring in normal service;
- f) except as permitted by the earth continuity test of IEC 60079-0, provide contact pressure that does not depend on the structural integrity of insulating materials;
- g) not be specified to accommodate more than one individual conductor in a clamping point unless specifically designed and assessed for doing so;
- h) if intended for stranded conductors, employ a means to protect the conductors and distribute the contact pressure evenly. The method of applying contact pressure shall be capable, on installation, of reliably forming the stranded conductor into an effectively solid shape that does not subsequently change in service. Alternatively, the method of applying the contact pressure should be such that it is designed to accommodate any settlement of the strands in service;
- i) for screw connections, have a torque value specified by the manufacturer;
- j) for screwless connections intended for class 5 and/or class 6 fine-stranded conductors according to IEC 60228, the fine-stranded conductor shall be equipped with a ferrule or the termination shall have a method to open the clamping mechanism so that the conductors are not damaged during the installation of the conductor.

NOTE 1 The use of aluminium wire can cause difficulties by compromising critical creepage and clearance distances when anti-oxidant materials are applied. The connection of aluminium wire to terminals is typically by the use of suitable bi-metallic connection devices providing a copper connection to the terminal.

NOTE 2 Special precautions against vibration and mechanical shock are often applied to reduce the risk of loosening.

NOTE 3 Electrolytic corrosion where ferrous materials are used can occur. Guidance on limitation of corrosion based on the limitation of electrochemical potential between dissimilar metals can be found in IEC TR 60943.

NOTE 4 The limiting temperature of the insulation of terminal blocks and accessories will usually be based on the limiting temperature of the insulation in accordance with item a) of 4.8.2 but the limiting temperature allocated to the terminal when used in equipment will also depend on the maximum cable insulation temperature rating of the cable which is to be connected.

4.2.2 Field wiring connections

4.2.2.1 General

Terminals for field wiring shall be dimensioned to allow the effective connection of conductors of cross-section equal to at least that required for the rated current of the electrical equipment.

Connections shall be located in a position so that when required to be inspected in service they are reasonably accessible.

The number, size, and type of conductors that can be safely connected shall be specified in the documentation prepared in accordance with IEC 60079-0.

NOTE 1 The 'type of conductor' includes features such as conductor material and stranding.

NOTE 2 Some types of cables, such as those used to conform to EMC requirements, include multiple earthing conductors. Facilities might be required for the termination of more earthing conductors than would normally be expected. In these cases, it is important that the user and the manufacturer coordinate the termination facilities to be provided.

4.2.2.2 Connections made using terminals conforming to IEC 60947-7-1, IEC 60947-7-2, IEC 60947-7-4, IEC 60999-1, or IEC 60999-2

Such terminals are intended for the connection of copper conductors with the insulation locally removed and without the addition of intermediate parts other than those replicating the form of a bare conductor, such as a ferrule.

Terminals in Level of Protection “eb” shall be subject to the terminal insulation material tests of 6.10.

Terminals shall be capable of being fixed in their mountings.

For terminals in Level of Protection “eb”, the temperature rise of the conductor bar shall not exceed 40 K at a test current of 110 % of rated current according to the method of the temperature-rise test of IEC 60947-7-1.

NOTE 1 This test relates to the absolute maximum current rating of the terminal when tested without any enclosure. For practical purposes, when terminals are used in multiples within enclosures, it will be necessary to establish reduced current ratings according to the particular circumstances. See 5.8, 6.8 and Annex E.

Terminals for connecting conductors of rated cross-section not exceeding 35 mm² (2 AWG) shall also be suitable for the effective connection of conductors at least two ISO wire sizes smaller, in accordance with Annex F, if not otherwise specified in the certificate.

NOTE 2 Subclause 4.2.2.2 is primarily intended to give requirements for terminals as Ex Components.

4.2.2.3 Integral field wiring connection facilities

Integral field wiring connection facilities shall meet the requirements of 4.2.2.2, as applicable.

NOTE 1 The connection facilities for equipment or Ex Components employing other types of protection, such as flameproof enclosure “d”, permit installation using increased safety “e” as the connection method.

NOTE 2 The 40 K rise referred to in 4.2.2.2 is only for the Ex Component evaluation of terminals and is not determined in the actual application of the terminal, where a rise of more than 40 K may be observed.

4.2.2.4 Connections designed to be used with cable lugs and similar devices

Such connections shall be fixed in their mountings.

Terminals shall meet the requirements of 4.2.2.1.

Terminals in Level of Protection “eb” shall be subject to the terminal insulation material tests of 6.10.

A means of securing the cable or conductors to prevent rotation or movement shall be provided to avoid either loosening or compromising creepage and clearance. Alternatively, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the provisions for securing the cable or conductors to avoid compromising creepage and clearance, and the provisions to avoid loosening of the connections. If the option to use marking instead of the “X” suffix is employed in accordance with IEC 60079-0, this marking may appear on either the exterior or the interior of the connection compartment.

NOTE Conductors of greater than 35 mm² can provide sufficient rigidity to avoid compromising creepage and clearance.

4.2.2.5 Connections using permanent arrangements

These connections are typically individual conductors (flying leads) that are intended to be terminated during installation using appropriate connection methods, see 4.2.1. Either a means of fixing the completed connections to a suitable location is to be provided or the completed connections are to be provided with means of reliably insulating them to the requirements of this standard.

If the method of connection is by soldering, a method of providing mechanical support of the completed connection, in addition to the solder, shall be provided. The mechanical support of the connection shall not be permitted to rely solely on the solder.

NOTE The intent of the mechanical support is to avoid mechanical stresses being transferred to the electrical connection.

4.2.3 Factory connections

4.2.3.1 General

Factory connections shall be either fixed in a specific location or be provided with means of meeting the creepage and clearance requirements of this standard.

Any of the connection methods suitable for use as field wiring connections may be used for a factory connection, except in this case, the terminal insulation material tests of 6.10 need not be conducted for either Level of Protection “eb” or “ec”.

NOTE The requirements for the thermal stability of the insulating material are given in 4.6.

4.2.3.2 Twist-on connectors for Level of Protection “ec”

In addition to the connection methods suitable for field wiring connections, twist-on connecting devices meeting the requirements of IEC 60998-2-4 may also be used for factory connections in Level of Protection “ec”.

4.2.3.3 Permanent connections

Permanent connections shall only be made by:

- a) crimping;
- b) brazing;

- c) welding;
- d) soldering, with mechanical support of the completed connection, in addition to the solder, provided; or
- e) In Level of Protection “ec”, printed circuit board mounted components, including surface-mount and through-hole mount components, **without** additional mechanical support

NOTE The process commonly referred to as 'silver soldering' is considered 'brazing'.

4.2.3.4 Pluggable connections for Level of Protection “eb”

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE 1 These connections are not intended to be connected or disconnected when an explosive atmosphere is present.

NOTE 2 Typical examples are plug-in components, and card edge connectors.

Pluggable connections in Level of Protection “eb” shall provide the following:

- a) each connection shall employ at least two areas of contact where the loss of one area of contact does not compromise the effectiveness of the other;
- b) if the factory connection can remain energized when separated, it shall be provided with an interlock to prevent separation when energized or shall be marked in accordance with item a) of Table 19. For small items, adjacent marking can be provided; and
- c) Connection secureness of either
 - each connection or group of connections shall be provided with a mechanical retaining device, which, excluding internal friction, provides a force resisting separation of at least 30 N with the force applied gradually near the centre of the component. Where a group of individual connections is mechanically linked and the separable component weighs more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection; or

NOTE 3 It is the intent that the effectiveness of the mechanical retention for Level of Protection “eb” be evaluated by test due to the increased risk of ignition due to separation of contacts in equipment of EPL Gb.

- for a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, the separating force in Newtons shall be greater than 200 times the weight (in kg) of the component, with the force applied gradually near the centre of the component. In this case, a mechanical retaining device is not required.

4.2.3.5 Pluggable connections for Level of Protection “ec”

These connections are designed to be readily connected or disconnected during assembly, maintenance, or repair.

NOTE 1 These connections are not intended to be connected or disconnected when an explosive atmosphere is present.

NOTE 2 Typical examples are connectors, plug-in components, and card edge connectors.

Sockets of pluggable connection for Level of Protection “ec”, which in normal operation do not have a plug inserted and which are intended to be used only for maintenance and repairing, are evaluated without the mating part inserted.

Pluggable connections in Level of Protection “ec” shall provide connection secureness using either of the following:

- a) Each connection or group of connections shall be provided with a mechanical retaining device, excluding internal friction, or shall provide a force resisting separation of at least 15 N with the separating force applied gradually near the centre of the component. Where

a group of individual connections is mechanically linked and the separable component weighs more than 0,25 kg or carries more than 10 conductors, special consideration shall be given to the security of the connection.

A means to evaluate the effectiveness of the mechanical retention is by the 15 N test described herein.

- b) For a connecting component relying on friction to remain in place and not attached in any way outside of the connection points, the separating force in Newtons shall be greater than 100 times the weight (in kg) of the component, with the force applied gradually near the centre of the component. In this case, a mechanical retaining device is not required.

4.2.3.6 Pluggable terminal bridging connections

These connections are intended to be made one-time only and not connected or disconnected during maintenance or repair. For Level of Protection “eb”, a terminal bridging connector shall have a separating force in Newtons that is greater than 200 times the weight (in kg) of the terminal bridging connector. The force shall be applied gradually near the centre of the terminal bridging connector.

For Level of Protection “ec”, a terminal bridging connector shall have a separating force in Newtons that is greater than 100 times the weight (in kg) of the terminal bridging connector. The force shall be applied gradually near the centre of the terminal bridging connector.

4.2.4 External plug and socket connections for field wiring connection

Plug and socket connections, where the flange plug or socket forms part of the wall of the enclosure, and the mating plug or socket is intended to be inserted externally, shall comply with the supplementary requirements of this sub-clause. The connections of the mating portion, if provided un-terminated, are considered field wiring.

Plugs and sockets for field wiring connections either:

- Between one piece of electrical equipment and another piece of electrical equipment (by means of a cable assembly involving plugs & sockets on both ends or a plug & socket on one end and un-terminated cable on the other), or
- Between the fixed installation and a piece of electrical equipment (by means of a cable assembly involving a socket on the equipment end and un-terminated cable on the fixed installation end),

shall comply with item a), b) or c) as follows:

- a) they shall be interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when plug and socket are separated;
- b) the equipment marked with the CONNECT / DISCONNECT marking as required by item a) of 9.4, and for Level of Protection “ec”, fixed together; for Level of Protection “eb”, fixed together by means of special fasteners.
- c) Where they cannot be de-energized before connection or disconnection according to b) above because they are connected to a battery, the marking shall state the separation warning required by item j) of 9.4.

Provision shall be made for the fixed part of a plug and socket connector to maintain the degree of protection of the enclosure on which it is mounted, even when the movable part has been removed. If the degree of protection is effectively reduced by accumulation of dust or water, provision shall also be made for maintaining an appropriate degree of ingress protection for the plug and/or socket.

4.3 Clearances

Clearances between bare conductive parts at different potentials shall be as given in Table 2 with a minimum value for field wiring connections of 3 mm for Level of Protection “eb” or 1,5 mm for Level of Protection “ec”. Alternatively, for Level of Protection “ec”, clearances for other than field wiring connections shall be permitted to conform to the values given in Annex H.

Spacings at wiring terminals shall be evaluated with and without the conductor to determine the minimum clearance under worst case conditions. Conductor arrangement shall be as specified by the manufacturer.

NOTE 1 The conductor arrangement by the manufacturer includes conductor sizes, conductor stripping dimensions, conductor ferrule usage, maximum screw torque, etc.

NOTE 2 A wiring terminal supplied with the conductor clamping arrangement fully open can present the worst case condition for spacings.

Clearances shall be determined as a function of the working voltage. Where the equipment is intended for more than one rated voltage or for a range of rated voltages, the value of working voltage to be used shall be based on the highest value of rated voltage. In determining the clearances, examples 1 to 11 (inclusive) in Figure 1 illustrate the features to be taken into account and the appropriate clearances.

Unless otherwise required in this standard, the enhanced clearance distances for equipment of Level of Protection “ec” only apply to mains circuits and between isolated circuits. The enhanced clearance distances do not apply to printed wiring board mounted components.

4.4 Creepage distances

4.4.1 The required values of creepage distance are dependent on the working voltage, the resistance to tracking of the electrical insulating material and its surface profile.

Spacings at wiring terminals shall be evaluated with and without the conductor to determine the minimum creepage.

Table 1 gives the grouping of electrical insulating materials according to the comparative tracking index (CTI) determined in accordance with IEC 60112. Inorganic insulating materials, for example glass and ceramics, do not track and need not therefore be subjected to the determination of the CTI. They are conventionally classified in material group I.

The grouping given in Table 1 is applied to insulating parts without ribs or grooves. If there are ribs or grooves in accordance with 4.4.3, the minimum permissible creepage distances for working voltages up to 1 100 V shall be based on the next highest material group, for example material group I instead of material group II.

NOTE 1 The material groups are identical with those given in IEC 60664-1.

Transient overvoltages are to be ignored as they do not normally influence tracking phenomena. However, temporary and functional overvoltages may have to be considered, depending upon the duration and frequency of occurrence.

Unless otherwise required in this standard, the enhanced creepage distances for equipment of Level of Protection “ec” only apply to mains circuits and between isolated circuits. The enhanced creepage distances do not apply to printed wiring board mounted components.

NOTE 2 See IEC 60664-1 for additional information.

Table 1 – Tracking resistance of insulating materials

Material group	Comparative tracking index (CTI)
I	$600 \leq \text{CTI}$
II	$400 \leq \text{CTI} < 600$
IIIa	$175 \leq \text{CTI} < 400$
IIIb	$100 \leq \text{CTI} < 175$

4.4.2 Creepage distances between bare conductive parts at different potentials shall be as given in Table 2, with a minimum value for field wiring connections of 3 mm for Level of Protection “eb” or 1,5 mm for Level of Protection “ec”, and shall be determined as a function of the rated voltage specified by the manufacturer of the equipment. Alternatively, for Level of Protection “ec”, creepage distances for other than field wiring connections shall be permitted to conform to the values given in Annex H.

4.4.3 In determining the creepage distance, Figure 1 illustrates the features to be taken into account and the appropriate creepage distance. The value of dimension 'X' is 2,5 mm for Level of Protection “eb” and 1,5 mm for Level of Protection “ec”.

The effects of ribs and grooves may be taken into account provided that:

a) For Level of Protection “eb”:

- ribs on the surface are at least 2,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 1,0 mm;
- grooves on the surface are at least 2,5 mm deep and at least 2,5 mm wide. If the associated clearance is less than 3 mm, the minimum groove width may be reduced to 1,5 mm.

b) For Level of Protection “ec”:

- ribs on the surface are at least 1,5 mm high and of a thickness appropriate to the mechanical strength of the material with a minimum value of 0,4 mm;
- grooves on the surface are at least 1,5 mm deep and at least 1,5 mm wide.

Projections above or depressions below the surface are considered as being either ribs or grooves, irrespective of their geometric form.

Constructions using cement (see IEC 60079-0) are considered to be solid parts.

NOTE The examples in Figure 1 are identical with those given in IEC 60664-1.

Table 2 – Minimum Creepage distances, clearances and separations

Voltage (see a and b) <i>U</i> _{r.m.s.} a.c. or d.c. V	Minimum creepage distance mm								Minimum clearances and separations mm		
	Material group								Clearance		Distance under coating ^d
	I		II		IIIa		IIIb				
	“eb”	“ec”	“eb”	“ec”	“eb”	“ec”	“eb”	“ec”	“eb”	“ec”	“ec”
≤10 (see c)	1,6	1	1,6	1	1,6	1	-	1	1,6	0,4	0,3
≤ 12,5	1,6	1,05	1,6	1,05	1,6	1,05	-	1,05	1,6	0,4	0,3
≤ 16	1,6	1,1	1,6	1,1	1,6	1,1	-	1,1	1,6	0,8	0,3
≤ 20	1,6	1,2	1,6	1,2	1,6	1,2	-	1,2	1,6	0,8	0,3
≤ 25	1,7	1,25	1,7	1,25	1,7	1,25	-	1,25	1,7	0,8	0,3
≤ 32	1,8	1,3	1,8	1,3	1,8	1,3	-	1,3	1,8	0,8	0,3
≤ 40	1,9	1,4	2,4	1,6	3,0	1,8	-	1,8	1,9	0,8	0,6
≤ 50	2,1	1,5	2,6	1,7	3,4	1,9	-	1,9	2,1	0,8	0,6
≤ 63	2,1	1,6	2,6	1,8	3,4	2	-	2	2,1	0,8	0,6
≤ 80	2,2	1,7	2,8	1,9	3,6	2,1	-	2,1	2,2	0,8	0,8
≤ 100	2,4	1,8	3,0	2	3,8	2,2	-	2,2	2,4	0,8	0,8
≤ 125	2,5	1,9	3,2	2,1	4,0	2,4	-	2,4	2,5	1	0,8
≤ 160	3,2	2	4,0	2,2	5,0	2,5	-	2,5	3,2	1,5	1,1
≤ 200	4,0	2,5	5,0	2,8	6,3	3,2	-	3,2	4,0	2	1,7
≤ 250	5,0	3,2	6,3	3,6	8,0	4	-	4	5,0	2,5	1,7
≤ 320	6,3	4	8,0	4,5	10,0	5	-	5	6,0	3	2,4
≤ 400	8,0	5	10,0	5,6	12,5	6,3	-	6,3	6,0	4	2,4
≤ 500	10	6,3	12,5	7,1	16	8	-	8	8,0	5	2,4
≤ 630	12	8	16	9	20	10	-	10	10	5,5	2,9
≤ 800	16	10	20	11	25	12,5	-	-	12	7	4
≤ 1 000	20	11	25	11	32	13	-	-	14	8	5,8
≤ 1 250	22	12	26	12	32	15	-	-	18	10	-
≤ 1600	23	13	27	13	32	17	-	-	20	12	-
≤ 2 000	25	14	28	14	32	20	-	-	23	14	-
≤ 2 500	32	18	36	18	40	25	-	-	29	18	-
≤ 3 200	40	22	45	22	50	32	-	-	36	22	-
≤ 4 000	50	28	56	28	63	40	-	-	44	28	-
≤ 5 000	63	36	71	36	80	50	-	-	50	36	-
≤ 6 300	80	45	90	45	100	63	-	-	60	45	-
≤ 8 000	100	56	110	56	125	80	-	-	80	56	-
≤ 10 000	125	71	140	71	160	100	-	-	100	70	-
≤ 12 500	-	90	-	90	-	125	-	-	-	89	-
≤ 13 640	-	98	-	98	-	138	-	-	-	97	-

^a When determining the required values for creepage and clearance, the working voltage may be higher than the voltage in the table by a factor of 1,1.

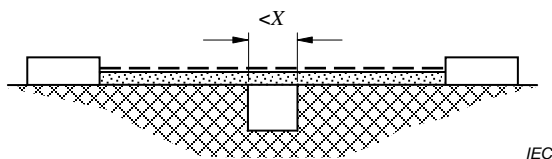
NOTE The factor of 1,1 recognizes that at many places in a circuit, the working voltage equals the rated voltage and that there are a number of rated voltages in common use that can be accommodated by the 1,1 factor.

^b The creepage distance and clearance values shown already take into account a maximum supply voltage tolerance of ±10 %. Therefore it is not necessary to further consider supply voltage fluctuations when determining which voltage value from the Table to use.

^c At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group IIIb may be acceptable.


^d The distances under coating shown are permitted for printed wiring boards in Level of Protection "ec" as described in 4.5.

Example 1

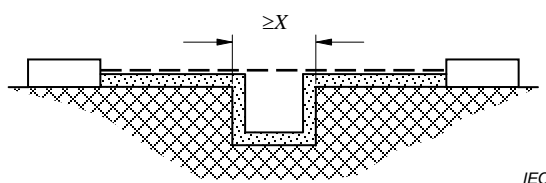


Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than X mm.

Rule: Creepage distance and clearance are measured directly across the groove as shown.

— — — — 1 clearance  2 creepage distance

Example 2

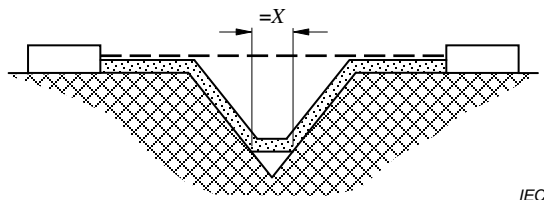


Condition: Path under consideration includes a parallel-sided groove of any depth d equal to or more than X mm.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove.

— — — — 1 clearance  2 creepage distance

Example 3

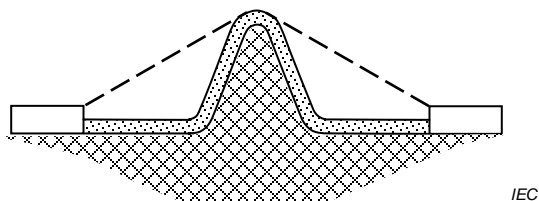


Condition: Path under consideration includes a V-shaped groove with a width greater than X mm.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the groove but 'short circuits' the bottom of the groove by X mm link.

— — — — 1 clearance  2 creepage distance

Example 4

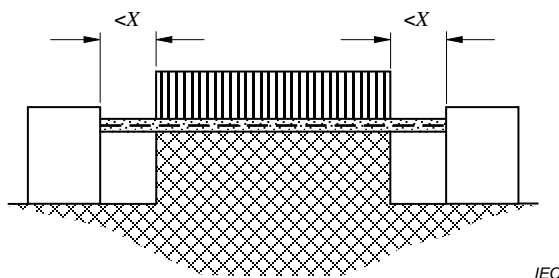


Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

— — — — 1 clearance  2 creepage distance

Example 5

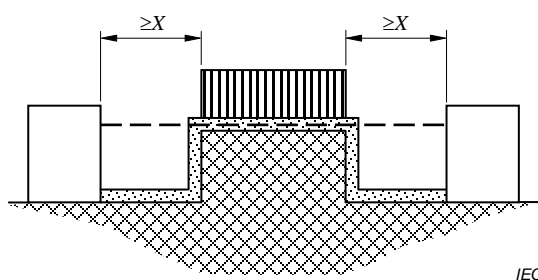


Condition: Path under consideration includes an uncemented joint with groove less than X mm wide on each side.

Rule: Creepage and clearance path is the 'line of sight' distance shown.

— — — — 1 clearance  2 creepage distance

Example 6

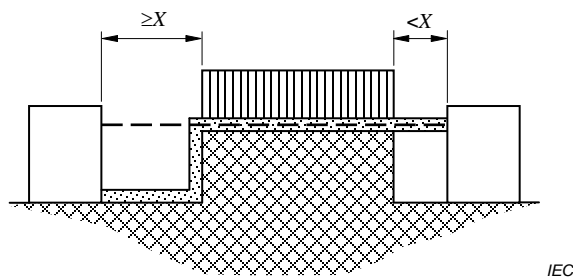


Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: Clearance is the 'line of sight' distance. Creepage path follows the contour of the grooves.

— — — — 1 clearance  2 creepage distance

Example 7



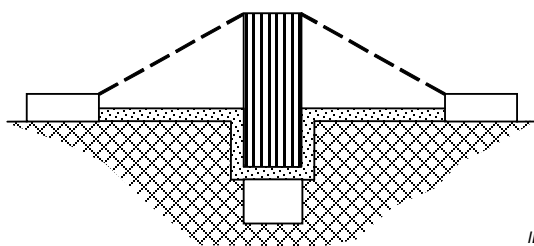
IEC

Condition: Path under consideration includes an uncemented joint with a groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

Rule: Clearance and creepage paths are as shown.

— — — — 1 clearance  2 creepage distance

Example 8



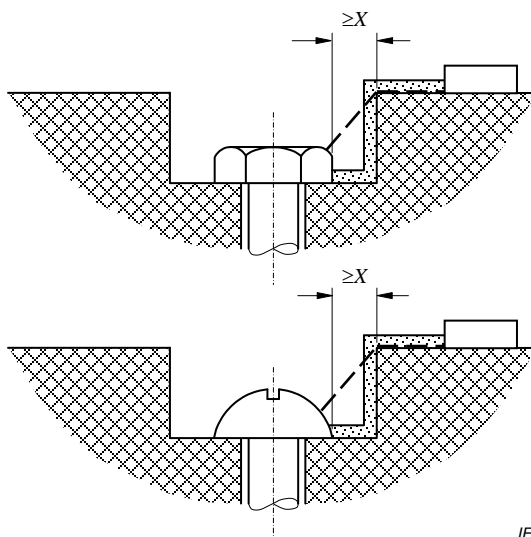
IEC

Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

Rule: Clearance is the shortest direct air path over the top of the barrier.

— — — — 1 clearance  2 creepage distance

Example 9

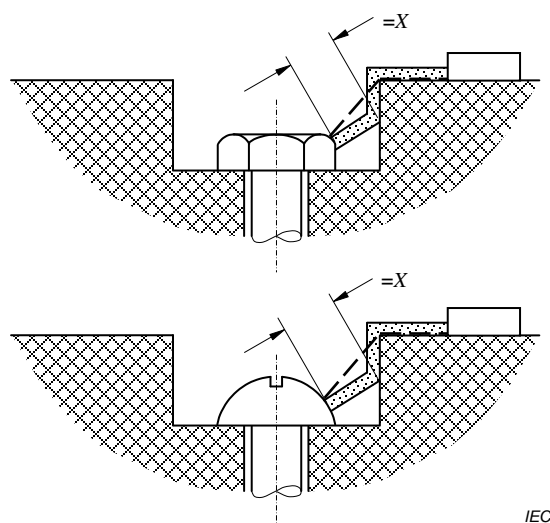


IEC

Gap between head of screw and wall of recess wide enough to be taken into account.

— — — — 1 clearance  2 creepage distance

Example 10



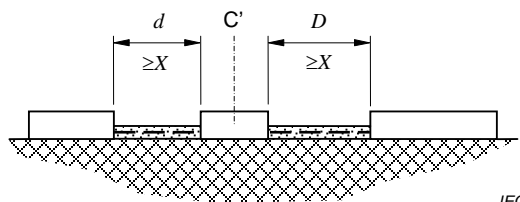
IEC

Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to X mm.

— — — — 1 clearance  2 creepage distance

Example 11



IEC

Clearance is the distance $d + D$

Creepage distance is also $d + D$

C' conductive part interposed in the insulating path between the conductors

— — — — 1 clearance  2 creepage distance

Figure 1 – Determination of creepage distances and clearances

4.5 Printed wiring boards with conformal coating, Level of Protection “ec”

For Level of Protection of “ec”, the reduced distances under coating shown in Table 2 are permitted for printed wiring boards with a working voltage not greater than 1 100 V. If applied, the coating shall have the effect of sealing the conductive parts and the insulating material in question against ingress of moisture. It shall adhere to the conductive parts and the insulating material. If the conformal coating is applied by spraying then two separate coats are to be applied. Other methods of application need only one coat, for example dip coating, brushing, vacuum impregnating, but the intention is to achieve an effective, lasting, unbroken seal. A solder mask alone is not considered as a conformal coating, but may be accepted as one of the two coats when an additional coat is applied, provided the solder mask is not damaged during soldering.

NOTE It is not the intent of 4.5 to increase the requirements for conformal coatings beyond those of general industrial equipment.

4.6 Solid electrical insulating materials

NOTE There are no specified distances through solid insulation in this standard, as the specified distances for normal industrial equipment, the requirements for the thermal stability of the insulating material, and dielectric tests are considered to provide the required level of safety for the applicable EPL.

4.6.1 Specification

The specification for insulating material relied upon for compliance with requirements in this standard shall include the following:

- a) the name or registered trademark of the material manufacturer;
- b) the identification of the material;
- c) the possible surface treatments, such as varnishes, etc.;
- d) long-term thermal stability of the material (such as the TI per IEC 60216, RTI per ANSI/UL 746B, or other rating systems establishing long term continuous operating temperature, e.g. 20 000 hour, ratings of the material),
- e) when applicable, the comparative tracking index (CTI) determined in accordance with IEC 60112;
- f) when the insulating material is part of the external enclosure, the temperature index TI, corresponding to the 20 000 h point on the thermal endurance graph without loss of flexural strength exceeding 50 %, determined in accordance with IEC 60216-1 and IEC 60216-2 and based on the flexing property in accordance with ISO 178. If the material does not break in this test before exposure to the heat, the index shall be based on the tensile strength in accordance with ISO 527-2 with test bars of Type 1A or 1B. As an alternative to the TI, the relative thermal index (RTI – mechanical) may be determined in accordance with ANSI/UL 746B.

The specification of the solid insulating material does not apply to interconnecting wiring or printed wiring board mounted components.

NOTE It is not a requirement of this standard that conformity to the manufacturer's specification of the insulating material needs to be verified.

4.6.2 Long-term thermal stability

The long-term thermal stability rating of the materials shall be:

- a) for Level of Protection “eb”, at least 20 K above the maximum service temperature, and at least 80 °C,
- b) for Level of Protection “ec”, at least the maximum service temperature, or for insulated windings, see 4.8.3 and Table 4.

The long-term thermal stability rating of the materials do not apply to printed wiring board mounted components.

Insulating parts made of plastics or laminates, where the original surface is removed during manufacture, shall be coated with an insulating varnish having at least the same grading according to CTI as the original surface. This requirement does not apply to materials where these actions have not affected the grading according to CTI or where the specified creepage distance is provided by other parts not subjected to these actions.

4.7 Windings

4.7.1 General

The requirements of 4.7.2 to 4.7.5 apply to Level of Protection “eb” only. For Level of Protection “ec”, there are no additional winding requirements beyond those of normal industrial equipment.

4.7.2 Insulated conductors

Insulated conductors shall conform to either one of the following requirements:

- a) The conductors shall be covered with at least two layers of insulation, only one layer of which may be enamel; or
- b) Enamelled round winding wires shall be in accordance with either:
 - grade 1 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 provided that:
 - when tested in accordance with Clause 13 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 there shall be no failure with the minimum values of breakdown voltage listed for grade 2; and that
 - when tested in accordance with Clause 14 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 there shall be not more than six faults per 30 m of wire irrespective of diameter; or
 - grade 2 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46; or
 - grade 3 of IEC 60317-3, IEC 60317-8, IEC 60317-13, or IEC 60317-46 .

NOTE It is not a requirement of this standard that conformity to the specification of the enamel grade be verified.

4.7.3 Winding impregnation

Windings, after having been fastened or wrapped, shall be dried to remove moisture before impregnation with a suitable substance. Except as limited herein, dipping, trickling or vacuum pressure impregnation (VPI) is acceptable. Coating by painting or spraying is not recognized as impregnation.

The impregnation shall be carried out in accordance with the specific instructions of the manufacturer of the impregnating substance used and in such a way that the spaces between the conductors are filled as completely as possible and that good cohesion between the conductors is achieved.

This does not apply to fully insulated coils and conductors of windings if, prior to their fitting into the electrical equipment, the slot portions and end windings of these coils and conductors have been impregnated, provided with filling material, or otherwise insulated in an equivalent manner, and if, after assembly, they are no longer accessible for the stated insulating procedures.

If impregnating substances containing evaporating solvents are used for dipping or trickling, the dipping or trickling and drying processes shall be carried out at least twice.

4.7.4 Conductor dimensions

The minimum nominal conductor dimension of wires used for windings shall be 0,25 mm.

NOTE: The minimum dimension is the diameter of a round conductor or the smallest dimension of a rectangular conductor.

4.7.5 Sensing elements

Sensing elements of resistance temperature detectors (RTDs) are not considered to be windings, but when applied to the windings of electrical machines, they shall be impregnated or sealed with the windings by the manufacturer.

When RTD's are applied in electrical machines with a rated voltage exceeding 1 kV, the RTD and its connecting leads shall be located in or adjacent to an earthed area. A means of satisfying this requirement is to locate the RTD between two winding layers, each of which is bound by a conductive covering prior to insertion in the slots. The RTD connecting leads could be routed adjacent to the core end immediately upon leaving the slot and routed to the terminal box avoiding any winding connections.

4.8 Temperature limitations

4.8.1 General

No solid electrical insulating material shall attain a temperature in excess of that defined by 4.6.2 when tested under rated conditions. Determination shall be in accordance with the procedure for the determination of Service Temperature in IEC 60079-0.

Furthermore, no surface of any part of electrical equipment, including the surface of internal parts to which the explosive gas atmosphere might have access, shall attain a temperature in excess of the maximum surface temperature prescribed in IEC 60079-0 except for lamps in luminaires for which the requirement is given in 5.3.7.2. The determination of the maximum surface temperature specified in IEC 60079-0 shall consider the additional overload or malfunction conditions defined in Table 3 of this standard and considering the test configuration described by the applicable industrial standard.

Table 3 – Conditions for the determination of maximum surface temperature

Type of electrical equipment	Overload or malfunction conditions in addition to the conditions of IEC 60079-0	
	Level of Protection "eb"	Level of Protection "ec"
Luminaires	Per 5.3	Per 5.3
Electrical machines	Per 5.2	None
Resistors	None	None
Terminals	None	None
Electromagnets	Worst-case air-gap	Worst-case air-gap
Other equipment	As specified by the applicable standard for industrial equipment	As specified by the applicable standard for industrial equipment as normal operating conditions

4.8.2 Conductors

In determining the temperature of the conductors, both the self-heating of the conductors and the effect of heating by neighbouring parts shall be taken into account.

The permissible temperature of conductors and other metal parts is further limited by:

- a) reduction of mechanical strength;
- b) unacceptable mechanical stress due to thermal expansion; and
- c) damage to neighbouring electrical insulating parts.

4.8.3 Insulated windings

The maximum temperatures of insulated windings shall not exceed the values given in Table 4 which take account of the thermal endurance of electrical insulating materials, provided that the electrical equipment still complies with the requirements of 4.8.1.

Table 4 – Maximum temperatures for insulated windings

	Method of temperature measurement	Thermal class according to IEC 60085 (see b)									
		105 (A)		120 (E)		130 (B)		155 (F)		180 (H)	
		"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"	"eb"	"ec"
Maximum service temperature (°C) under normal operation: insulated single layer winding	Resistance or thermometer	95	105	110	120	120	130	130	150	155	175
Maximum service temperature (°C) under normal operation: other insulated windings	Resistance	90	100	105	115	110	120	130	145	155	165
	Thermometer (See a)	80	N/A	95	N/A	100	N/A	115	N/A	135	N/A
	Embedded sensor Output > 5 MW or 5 MVA	95	105	110	120	120	125	135	150	160	170
	Embedded sensor >200 kW or 200 kVA ≤ Output ≤ 5 MW or 5 MVA	95	105	110	120	120	130	135	155	160	175
Maximum motor winding temperature (°C) at end of time t_E or at time of switch off by embedded temperature sensor (see c)	Resistance	160	N/A	175	N/A	185	N/A	210	N/A	235	N/A
<p>The sensor may be inside and/or outside the electrical equipment.</p> <p>Electrical faults in insulated windings are excluded. The requirements of 4.7 and 4.8 are intended to reduce the likelihood of such faults.</p> <p>a Measurement by thermometer is permissible only when measurement by change of resistance is not possible. In this context, 'thermometer' has the same meaning as in IEC 60034-1 (for example, a bulb thermometer, or a non-embedded thermocouple or resistance temperature detector (RTD) applied to the points accessible to the usual bulb thermometer).</p> <p>b As an interim measure until values have been prescribed, the higher thermal classes of insulating material denoted by figures in IEC 60085 are considered as subject to the limiting temperatures given for class 180 (H).</p> <p>c These values result from the summation of the effects of ambient temperature, the temperature rise of the winding in rated service and the further increase of temperature during time t_E. Where the motor winding is protected by embedded sensors, the temperature is determined at the time the motor is switched off after the locked rotor.</p>											

4.9 Wiring internal to equipment

Wiring which might come into contact with a conductive part shall be mechanically protected, secured, or routed to avoid insulation damage.

4.10 Degrees of protection provided by enclosures

4.10.1 The degrees of protection as defined in tests of enclosures of IEC 60079-0, as applicable, shall be as prescribed in a), b), or c) unless otherwise specified in 4.10.2, 4.10.3, or Clause 5. For Level of Protection “ec”, the tests of enclosures requirements of IEC 60079-0 are modified for the thermal endurance to heat preconditioning test to replace the 20 K above the service temperature ($T_s + 20$ K) with 10 K above the service temperature ($T_s + 10$ K).

- a) Enclosures containing bare conductive live parts shall provide at least the degree of protection IP54.
- b) Enclosures containing only insulated conductive live parts as in 4.6 shall provide at least the degree of protection IP44.
- c) Enclosures for containing only insulated conductive live parts as in 4.6, can provide a reduced degree of protection of IP23 for Group I, or IP20 for Group II, if solid foreign bodies are prevented from falling vertically through any openings into the enclosure. For this equipment, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the degree of protection provided by enclosure and provide guidance on the protection by location that is required. An example of an application where this reduced degree of protection could be suitable is a clean environment.

For Level of Protection “ec”, opening of the enclosure for maintenance purposes, is not considered normal operation, and the opening times requirement of IEC 60079-0 does not apply.

NOTE: The degree of protection requirements from general industrial standards are not applied directly for the evaluation of the explosion protection of Ex Equipment.

The bars and rings of rotor cages are not considered to be bare live parts when determining the degree of protection.

4.10.2 The enclosure of electrical equipment may be provided with drain holes or ventilation openings to prevent the accumulation of condensation. The requirements are dependent upon the equipment grouping as follows:

- a) Equipment Group I – compliance with 4.10.1 is required.
- b) Equipment Group II – the inclusion of the drain holes or ventilation openings may reduce the degree of protection provided by the enclosure according to 4.10.1, but shall not be below IP44 for item a) of 4.10.1 or IP24 for item b) of 4.10.1.

When the presence of drain holes or ventilation openings reduces the degree of protection below the requirements of 4.10.1, the details of the drain holes or ventilation openings, including position and dimensions, shall be stated by the manufacturer and included in the descriptive documents in accordance with IEC 60079-0. For equipment with drain holes and ventilation openings that reduce the degree of protection, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the reduced degree(s) of protection provided by enclosure and note that environmental dust may enter the enclosure and compromise the electrical creepage and clearance.

4.10.3 When there are circuits or apparatus with Type of Protection “i” where live maintenance has been permitted by the instructions, in accordance with IEC 60079-11 within the enclosure, either:

- a) the covers of the enclosure permitting access to energized non-intrinsically-safe circuits or apparatus shall have a label per item b) of Table 19; or
- b) all bare live parts not protected by the Type of Protection “i” shall have a separate internal cover providing at least the degree of protection IP30 when the enclosure of the equipment is open.

In addition, the internal cover shall have a label per item c) of Table 19 or other wording that would otherwise be required by IEC 60079-0 to be on the cover of the enclosure of the equipment.

The cover of the enclosure of the equipment shall have a label per item d) of Table 19.

NOTE The purpose of the internal cover, when fitted, is to provide a minimum acceptable degree of protection against the access to energized non-intrinsically-safe circuits when the enclosure is opened for short periods to permit live maintenance of intrinsically-safe circuits. The cover is not intended to provide protection from electrical shock.

4.11 Fasteners

For Group I electrical equipment containing bare live parts, special fasteners in accordance with IEC 60079-0 shall be used.

5 Supplementary requirements for specific electrical equipment

5.1 General

These requirements supplement those of Clause 4 of this standard which are applicable also, unless otherwise stated, to the specific electrical equipment considered in 5.2 to 5.9 and also to the other electrical equipment considered in 5.10.

These requirements apply to both Levels of Protection “eb” and “ec”, unless otherwise noted.

5.2 Electrical machines

5.2.1 General

The requirements in this clause apply to rotating electrical machines within the scope of IEC 60034-1.

For other rotating devices, for example servo motors, the requirements of this standard including those of this clause, shall apply where they are appropriate.

For non-rotating machines, for example linear motors, the requirements of this standard including those of this clause, shall apply where they are appropriate.

NOTE 1 The requirements of this standard for Level of Protection “ec” assume that the occurrence of an explosive gas atmosphere and a motor start sequence do not occur simultaneously, and Level of Protection “ec” is not generally suitable in those cases where these two conditions do occur simultaneously. Motors of Level of Protection “ec” with an elevated risk of rotor sparking, see 5.2.7, are not intended to be used where the probability of an explosive gas release cannot be totally disassociated with the start sequence as an independent event. The oil seal systems of centrifugal compressors are known to produce such releases during starting.

NOTE 2 'Normal' operating conditions for electrical machines for Level of Protection “ec” are assumed to be rated full-load steady conditions. Starting (acceleration) of rotating electrical machines is excluded as part of 'normal' operation for Level of Protection “ec” under duty S1, S2, S6, or S9. Due to the potential for more frequent starts of motors with duty S3, S4, S5, S7, S8, or S10, the requirements for rotor sparking address the risk of rotor sparking during starting as a 'normal' condition. The definitions of duty S1 to S10 are in IEC 60034-1.

NOTE 3 Motors (such as cooling fans and disc drive motors) with all of the following characteristics, are outside of the scope of IEC 60034-1;

- a brushless motor with a power rating less than 100 W (as defined in IEC 60950)
- operating at Extra Low Voltage levels (not more than 42,4 V peak or 60 V d.c. as defined in IEC 60950)
- used in Level of Protection “ec” electronic equipment.

For those motors, the requirements of this standard, excluding Clause 5, would be applied where they are appropriate. Additional information on separation distances is given in Annex A.

NOTE 4 Additional guidance on temperature testing of electrical machines is given in Annex A.

5.2.2 Degrees of protection provided by electrical machines, Level of Protection “eb”

The requirements of 4.10 apply.

5.2.3 Degrees of protection provided by electrical machines, Level of Protection “ec”

The requirements of 4.10 apply, except that terminal boxes attached to electrical machines operating at voltages up to 1 kV, may be opened to the interior of the machine, only when the degree of protection of the electrical machine is at least IP44. Covers and entries of the terminal box shall provide at least degree of protection IP54.

NOTE For test purposes, the interface of the terminal box to the electrical machine enclosure can be simulated with a blanking plate replacing the electrical machine enclosure. The normal seal or gasket is used in the interface. For the IP5X dust test, the volume to be used for the extraction calculations is the free internal volume of only the terminal box.

5.2.4 Connection facilities for external conductors

The connection facilities of electrical machines shall conform to 4.2.2. The service temperature of terminal box cover gaskets and seals, the cable branching point temperature, and the entry point temperature shall be considered to be equal to the maximum temperature determined in the air space of the terminal box during normal load temperature testing of the electrical machine. See A.2. If there is a gasket or seal between the terminal box and the machine frame, the maximum service temperature of that gasket or seal shall be determined.

NOTE 1 The use of the internal air space temperature to represent the service temperature of terminal box gaskets and seals, the cable branching point temperature, and the entry point temperature reflects the normal practice of testing machines without prior knowledge of the actual glands and cables to be used for installation. The production of heat from the electrical machine connections is generally insignificant with respect to the production of heat from the machine windings and core.

NOTE 2 Due to the size of cables and glands employed with large rotating electrical machines, a 'gland plate assembly' is often applied to allow the cable and glands to be removed from the terminal box as an assembly, thus avoiding damage to the terminal box, damage to the cable sealing, damage to the cable gland, or subjecting the cable to stresses liable to damage the cable insulation or the conductors.

5.2.5 Internal fans

Internal fans shall conform to the requirements for clearances and materials specified for external fans in IEC 60079-0.

5.2.6 Minimum air gap

An air gap shall be specified in the documentation prepared in accordance with IEC 60079-0. This shall be sufficient to avoid contact between stator and rotor and compliance shall be demonstrated by one of the following means:

- a) measurement of the air gap of the test sample;
- b) calculation of the minimum air gap;

NOTE 1 It is acknowledged that, with assemblies, all parts will not exist at the worst case dimensions simultaneously. A statistical treatment of the tolerances, such as 'RMS', might need to be applied to demonstrate adequate minimum radial air gap.

NOTE 2 It is not a requirement of this standard that the manufacturer's gap calculations be verified. Also, it is not a requirement of this standard that the gap be verified by measurement.

NOTE 3 Constructions a) and b) are commonly applied to machines employing either a radial flux path or an axial flux path.

NOTE 4 When applied to linear motors, the “air gap” often include anti-frictional slides used to avoid contact.

- c) machines employing a radial flux path may have a radial air gap construction in accordance with the following equation:

Minimum radial air gap, in mm:

$$\left[0,15 + \frac{D - 50}{780} \left(0,25 + \frac{0,75n}{1000} \right) \right] rb \quad (1)$$

where

D is the rotor diameter, in mm, which in the formula for the minimum radial air gap is subject to a minimum value of 75 mm and a maximum value of 750 mm;

n is the maximum rated speed in r/min and is subject to a minimum value of 1 000;

r has the value given by the following formula and is subject to a minimum value of 1,0:

$$r = \frac{\text{core length}}{1,75 \times \text{rotor diameter, } D} \text{ in mm} \quad (2)$$

b has the value of 1,0 for machines with rolling bearings or 1,5 for machines with plain bearings.

NOTE 5 The minimum radial air gap is not directly proportional to the supply frequency or number of poles as can be seen from the example of a 2-pole or 4-pole motor with rolling bearings designed for a 50 Hz/60 Hz supply and having a rotor with a diameter of 60 mm and a core length of 80 mm.

D is then taken as 75, the minimum value;

n as 3 600, the maximum value;

b as 1,0;

$r = 80/(1,75 \times 60)$, i.e. approximately 0,76 and therefore taken as 1,0

when the minimum radial air gap becomes:

$$\left[0,15 + \frac{75 - 50}{780} \left(0,25 + \frac{0,75 \times 3\,600}{1\,000} \right) \right] 1,0 \times 1,0 \quad (3)$$

or approximately 0,25 mm.

5.2.7 Rotating electrical machines with cage rotors

5.2.7.1 General

In addition to the requirements of 5.2.2, 5.2.3, 5.2.4, 5.2.5 and 5.2.6, the requirements of this subclause apply to rotating electrical machines with cage rotors, including synchronous machines with 'cage rotor' starting or damping windings.

NOTE Synchronous machines include permanent magnet machines with 'cage rotor' starting or damping windings, see 5.2.9.

5.2.7.2 Rotor cages

5.2.7.2.1 Rotor cages built from bars connected to end rings

The bars of cage rotors shall fit tightly in the slots and the joints between bars and short-circuiting rings shall be brazed or welded and compatible materials shall be used to enable high quality joints to be made.

5.2.7.2.2 Cast rotor cages

Cast rotor cages shall be made by pressure die-casting or centrifugal casting, equivalent techniques, or otherwise fit tightly in the slots.

The bars and rings of cage rotors are not considered to be bare conductive parts in applying 4.4, 4.10, 5.2.2, and 5.2.3.

5.2.7.3 Assessment for possible air gap sparking

Rotating electrical machines shall be assessed for possible air gap sparking as follows. For Level of Protection “ec” this assessment shall only be required for machines with a rated output exceeding 100 kW with duty types S3, S4, S5, S7, S8, or S10. If the total sum of the factors determined by Table 5 is greater than 6, one of the following additional protective measures shall be applied:

- a) The machine or a representative sample shall be tested in accordance with 6.2.3.2.
- b) The machine design shall allow special measures to be applied during starting, to ensure that its enclosure does not contain an explosive gas atmosphere at the time of starting. In this case, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the special measures to be applied.
- c) The starting current of the machine is required to be limited to 300 % of rated current, I_N . When external current limiting is required, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail that the motor is suitable only for reduced voltage starting which limits the starting current to 300 % of the rated current.

NOTE 1 Special measures include pre-start ventilation to remove any ignitable accumulation of flammable gases (for example by applying the purging, but not pressurization aspects of IEC 60079-2 in respect of Level of Protection “pzc”) or the application of fixed gas detection (see IEC 60079-29-2) inside the machine enclosure to confirm that the machine is free of ignitable concentrations of flammable gases. Other methods are carefully coordinated between the manufacturer and the user.

NOTE 2 For motors driving high inertia loads or intended to be auto re-started, these tests are only representative of operating conditions away from torsional resonance of the complete drive train and where out-of-phase restarting can be excluded. These special applications are carefully coordinated between the manufacturer and the user.

NOTE 3 Operation of a motor with a converter to provide the current limitation is generally an acceptable solution. For other reduced voltage starting methods, the motor and the reduced-voltage starter need to be carefully coordinated.

**Table 5 – Potential air gap sparking risk assessment
for cage rotor ignition risk factors**

Characteristic	Value	Factor
Rotor cage construction	Uninsulated bar fabricated rotor cage	3
	Open slot cast rotor cage ≥ 200 kW per pole	2
	Open slot cast rotor cage < 200 kW per pole	1
	Closed slot cast rotor cage	0
	Insulated bar rotor cage	0
Number of poles	2-pole	2
	4-pole to 8-pole	1
	> 8 -pole	0
Rated output	> 500 kW per pole	2
	> 200 kW to 500 kW per pole	1
	≤ 200 kW per pole	0
Radial cooling ducts in rotor	Yes: $L < 200$ mm (see a)	2
	Yes: $L \geq 200$ mm (see a)	1
	No	0
Rotor or stator skew	Yes: > 200 kW per pole	2
	Yes: ≤ 200 kW per pole	0
	No	0
Rotor overhang parts	Non-compliant (see b)	2
	Compliant (see b)	0
Limiting temperature	> 200 °C	2
	135 °C $< T \leq 200$ °C	1
	≤ 135 °C	0
<p>^a L is the length of end packet of core. Experimental tests have shown that sparking occurs predominantly in ducts near the ends of the core.</p> <p>^b Rotor overhang parts should be designed to eliminate intermittent contact and to operate within the temperature classification. Compliance with this ruling gives a factor of 0, otherwise it is 2.</p>		

5.2.8 Limiting temperature

5.2.8.1 Limiting temperature of rotor

For rotating electrical machines with cage rotors, including synchronous machines with 'cage rotor' starting or damping windings, the limiting temperature of the rotor shall not exceed 300 °C for uninsulated rotor cage constructions or the temperature limitation determined by 4.8 for insulated rotor cage constructions. For Level of Protection "eb" motors of duty types S1 to S10 and Level of Protection "ec" motors of duty types S3, S4, S5, S7, S8, or S10, the limiting temperature of the rotor shall not be exceeded, even under starting conditions.

NOTE 1 Parts such as retaining rings, balance disks, centring rings, fans or air shrouds located in the leakage flux path, unless insulated or non-magnetic, often exceed the limiting temperature of the rotor during starting conditions

NOTE 2 The temperature of permanent magnet rotors are not expected to exceed the maximum temperature rating of the magnets as demagnetization of the magnets could occur, potentially changing the heating of the machine.

NOTE 3 Synchronous machines include permanent magnet machines with 'cage rotor' starting or damping windings, see 5.2.9.

5.2.8.2 Limiting temperature by current-dependent safety device

For rotating machines of Level of Protection “eb” intended for line starting protected by a current-dependent safety device to protect against exceeding the limiting temperature, the starting current ratio I_A/I_N and the time t_E shall be determined in accordance with 6.2.1 and marked in accordance with 9.1.

The length of time t_E shall be such that, when the machine is stalled, it can be disconnected by the current-dependent safety device before time t_E has elapsed. In general, this is possible if the minimum values for t_E given in Figure 2 as a function of the starting current ratio I_A/I_N are exceeded. Values of time t_E below the values in Figure 2 are permissible only if a suitable current-dependent safety device is used for the machine and it is shown to be effective by test. The current-dependent safety devices shall be specified by marking on the machine in accordance with item g) of 9.1.

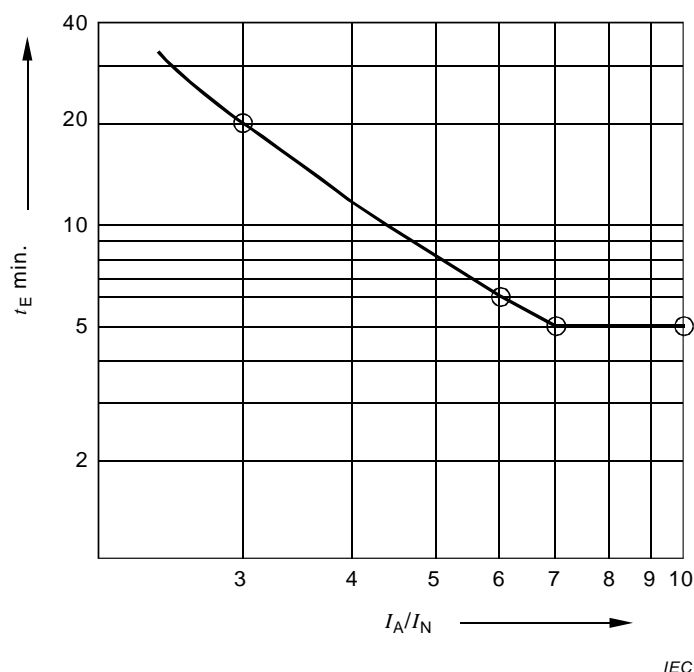


Figure 2 – Minimum values of the time t_E (in seconds) of motors in relation to the starting current ratio I_A/I_N

In no case,

- a) shall the value of time t_E be less than 5 s when using a current-dependent safety device,
- b) shall the value of the starting current ratio I_A/I_N exceed 10.

NOTE 1 Information on the thermal protection of Level of Protection “eb” cage motors by overload protective devices is given in Annex C.

NOTE 2 Thermal protection of Level of Protection “ec” machines during expected malfunctions is provided by the general industrial requirements and no additional safety devices are necessary to maintain the explosion protection.

5.2.8.3 Limiting temperature by temperature and other sensors

Even for rotating machines of Level of Protection “eb” intended for use with winding temperature sensors associated with safety devices to protect against exceeding the limiting temperatures, the starting current ratio I_A/I_N shall be determined and marked in accordance with 9.1. Time t_E is not required to be determined and marked.

For polyphase machines, there shall be a minimum of one sensor per phase.

Winding temperature sensors associated with safety devices shall be considered adequate for the thermal protection of the machine if the requirements of 4.8 are satisfied even with the rotor locked, other than duty types S1, S2, S6, or S9 in Level of Protection “ec”. The requirements for associated safety devices shall be specified by marking on the machine in accordance with item g) of 9.1.

In no case shall the value of the starting current ratio I_A/I_N be more than 10.

A converter may serve as the safety device in conjunction with the winding temperature sensors. See 5.2.8.4.

Speed sensors, impedance relays, rate-of-rise sensors, etc. along with associated safety devices may also be used to limit the rotor temperature.

NOTE 1 For machines that are rotor limited, it is not generally practical to limit the rotor temperature by the use of stator winding temperature sensors alone. Additional considerations such as different rates of rise and selection of the tripping point of the sensor might be relevant.

NOTE 2 Thermal protection of Level of Protection “ec” machines during expected malfunctions is provided by the general industrial requirements and no additional safety devices are necessary to maintain the explosion protection.

5.2.8.4 Operation with a converter or a non-sinusoidal supply

5.2.8.4.1 General

To prove that the limiting temperature (5.2.8) is not exceeded throughout the operational speed range, two methods may be used: a type test or verification by calculation.

5.2.8.4.2 Type test with a converter

Machines intended to be operated with a converter shall be tested with the specified converter or with a comparable converter with respect to the output voltage, output current, and switching frequency specifications to confirm that the machine limiting temperatures (5.2.8) are not exceeded. The descriptive documentation for the machine shall include the necessary parameters and conditions required for use with a converter.

- a) For Level of Protection “eb” machines of duty type S1 to S10, the test conditions shall include normal operation at rated conditions, continuous overload, and starting.
- b) For Level of Protection “ec” machines of duty type S1, S2, S6, or S9; the test conditions shall include normal operation at rated conditions.
- c) For Level of Protection “ec” machines of duty type S3, S4, S5, S7, S8, or S10, the test conditions shall include normal operation at rated conditions and starting.

NOTE Additional information on the operation of motors with a converter can be found in IEC TS 60034-25. Major concerns include over-temperature, high frequency and over-voltage effects, bearing currents and requirements for high frequency earthing. There are currently no IEC standards specifically dealing with the operation of permanent magnet motors with a converter.

5.2.8.4.3 Alternative type verification by calculation

The limiting temperature is not to be exceeded under the following conditions. This may be confirmed by calculation which shall be based on previously established representative test data.

- a) For Level of Protection “eb” machines of duty type S1 to S10, the conditions shall include normal operation at rated conditions, continuous overload, and starting.
- b) For Level of Protection “ec” machines of duty type S1, S2, S6, or S9; the conditions shall include normal operation at rated conditions.

- c) For Level of Protection “ec” machines of duty type S3, S4, S5, S7, S8, or S10, the conditions shall include normal operation at rated conditions and starting.

NOTE The temperature differential between stator and rotor of a machine operating with a non-sinusoidal supply, or generating into a thyristor load, can vary greatly from the temperature differential that would occur on the same machine operating with a sinusoidal supply, or generating into a linear load. Therefore the rotor temperature might become the limiting feature of the machine, particularly in the case of rotor cage windings.

5.2.9 Machines with permanent magnet rotors

5.2.9.1 Construction

Magnets shall be secured to the rotor. Securing shall be confirmed by the overspeed test in 6.2.4. If the magnets are secured to the rotor solely by cement, the rotor shall be subjected to thermal endurance tests based on its service temperature prior to the overspeed test. For Level of Protection “ec”, the tests of enclosures requirements of IEC 60079-0 are modified for the thermal endurance to heat preconditioning test to replace the 20 K above the service temperature ($T_s + 20$ K) with 10 K above the service temperature ($T_s + 10$ K).

Except for machines in Level of Protection “ec”, duty types S1, S2, S6, or S9 supplied directly from a 50 Hz or 60 Hz supply, the stator winding system shall be protected with embedded temperature sensors, one per phase.

Permanent magnet synchronous motors usually require a starting winding for fixed frequency sinusoidal supply starting. Stable operation of permanent magnet synchronous motors may also require damping windings of some kind. For both of these windings, the requirements of 5.2.7.2 and 5.2.8.1 apply.

Permanent magnet motors will operate as a generator while coasting after power is removed. For motors of Level of Protection “eb”, where the voltage can be greater than the rated voltage, creepage and clearance and the winding insulation system shall be suitable for the voltages that will result.

5.2.9.2 Operating from fixed frequency sinusoidal supply

The requirements of 5.2.8 apply.

5.2.9.3 Operation with a converter

The requirements of 5.2.8.4 apply.

5.2.10 Stator winding insulation system

For all stators with a rated voltage above 1 kV, the machine shall be fitted with anti-condensation heaters.

For Level of Protection “eb” machines, if the rated voltage exceeds 1 kV, type tests in accordance with 6.2.3.1.2 and 6.2.3.1.3 shall be conducted.

For Level of Protection “ec” machines, if the rated voltages exceed those shown in Table 6 for the applicable equipment groups, type tests of the stator winding insulation system shall be conducted in accordance with 6.2.3.1.3.

Table 6 – Stator insulation system tests of Level of Protection “ec” machines

Rated Voltage	Equipment Group
> 1 kV	IIB or IIC
> 1 Kv with random-wound stator	IIA
> 6,6 kV with form-wound stator	IIA

It is recommended that partial discharges be minimized for all high-voltage windings. For windings with a rated voltage of 6,6 kV, or greater, the use of partial discharge suppressant materials is recommended.

5.2.11 Supplemental winding requirements Level of Protection “eb”

For polyphase windings rated 200 V or higher, supplemental phase insulation (in addition to varnish) shall be provided between the phases of random windings.

The minimum clearance between a stator winding overhang and the enclosure shall not be less than 3 mm.

For windings rated <1 000 V, the requirements for coil impregnation shall be either those of 4.7.3 or those applying to windings rated >1 000 V.

For windings rated >1 000 V, coils shall be from a form-wound and VPI insulation system or a resin-rich insulation system.

5.2.12 Bearing seals and shaft seals

5.2.12.1 Machines of Level of Protection “eb” shall conform to the requirements of 5.2.12.2 and 5.2.12.3. Machines of Level of Protection “ec” have no additional bearing seal and shaft seal requirements beyond those of normal industrial equipment.

5.2.12.2 Non-rubbing seals and labyrinths

For rolling element bearings the minimum radial or axial clearance between the stationary and rotating parts of any non-rubbing seal or labyrinth seal shall be not less than 0,05 mm. For sliding element (sleeve) bearings, this clearance shall be 0,1 mm. The minimum clearance shall apply for all possible positions of the shaft within the bearings.

NOTE The axial movement in a typical ball bearing is likely to be up to 10 times the radial movement.

5.2.12.3 Rubbing seals

Rubbing seals shall be either lubricated or made of material having a low coefficient of friction, for example polytetrafluoroethylene (PTFE). In the former case, the design of the bearing shall be such that a supply of lubricant to the seal is maintained.

Bearings with covers supplied as an integral part of the bearing by the bearing manufacturer (that is to say, 'sealed for life' bearings) are exempt from this requirement.

Rubbing seals shall be assessed in accordance with 4.8.

Rubbing seals which reduce their cross-section when ageing (for example felt sealing rings) are considered to meet the requirements when the temperature is assessed to be within the limits during new condition. Elastic seals which lift off during rotation (for example V rings) are also considered to meet the requirements.

NOTE At the present time, no suitable experimental test exists to demonstrate that a given type of bearing has a very low risk of failing in service. It is therefore paramount that the manufacturer pays attention to good design, construction, lubrication, cooling, monitoring and/or maintenance procedures, in an attempt to minimize the risk of a potential ignition source arising from a rolling bearing failure.

5.2.13 Neutral point connections

In the case of neutral point connections which are not intended for use as an alternative supply connection to the machine, the minimum creepage and clearance requirements shall be determined according to the assumed voltage given in Table 7.

Table 7 – Assumed voltage of neutral points

voltage <i>U</i> a.c., r.m.s or d.c. V	Assumed voltage of neutral point V
$\leq 1\,000$	<i>U</i>
1 000 < <i>U</i> ≤ 3 200	1 000
3 200 < <i>U</i> ≤ 6 300	3 200
6 300 < <i>U</i> ≤ 10 000	6 300
10 000 < <i>U</i> ≤ 15 000	10 000
When determining the required values for creepage and clearance, the working voltage may be higher than the voltage in the table by a factor of 1,1.	

In the case of neutral point connections within the enclosure of the machine, the neutral connection shall be fully insulated unless the ingress protection is IP44 or greater and the machine is not intended to be connected to an earthed line supply.

5.3 Luminaires, hand lights, or caplights

5.3.1 General

The supplemental requirements given in 5.3 apply to all luminaires (fixed, portable, or transportable), hand lights, and caplights (other than for Group I); intended to be supplied by mains (with or without galvanic isolation) or powered by batteries.

NOTE 1 Hand lights include battery-powered lights which are also referred to as torches or flashlights.

The whole of the lamp(s) shall be enclosed within the light transmitting cover as part of the luminaire.

For luminaires with more than one field wiring entry, where the entries are to be used for looping the supply and earthing conductors, those looping connections shall be provided.

Light sources mounted within other equipment shall conform to the relevant requirements of this clause.

Luminaires with lampholders are intended to be resistant to vibration. The tests for bi-pin luminaires, in Level of Protection “eb”, are given in this standard. For other luminaires, the manufacturer shall provide a declaration confirming that the vibration tests for “rough service luminaires” in IEC 60598-1 have been conducted with satisfactory results.

NOTE 2 The construction and testing requirements for Group I caplights are given in IEC 60079-35-1.

NOTE 3 Vibration tests of lampholders are conducted on complete luminaires as the results are dependent upon the mounting arrangements of the lampholders.

NOTE 4 The minimum spring forces for screw-type or bayonet-type lampholders provide a degree of protection against vibration. See 5.3.5.5.

5.3.2 Light source

5.3.2.1 General

Lamps with internal ignitors can cause high-voltage transients which can damage ballasts or electronic ignitors. Such lamps shall not be specified for use with luminaires having Level of Protection “eb” or “ec”.

5.3.2.2 Lamps

Unless alternatively specified in 5.3.2.3, 5.3.2.4, or 5.3.2.5, the lamp specified for use with the luminaire shall be one of the following:

- a) for Level of Protection “eb” or “ec”, fluorescent lamps of the cold starting type in accordance with IEC 60081 with single-pin caps (Fa6) in accordance with IEC 60061-1;
- b) for Level of Protection “eb” or “ec”, tubular fluorescent bi-pin lamps in accordance with IEC 60081 with G5 or G13 lamp caps in accordance with IEC 61195 with pins made of brass. Lampholders and sockets shall conform to 5.3.5.3. Such lamps shall be connected in a circuit in which they start and run without preheating of the cathodes; only T8, T10, or T12 lamps shall be used. T5 lamps shall be permitted only up to 8 watts.
- c) for Level of Protection “ec”, tubular fluorescent bi-pin lamps in accordance with IEC 60081 with G5 or G13 lamp caps in accordance with IEC 61195 with pins made of brass. Lampholders and sockets shall conform to 5.3.5.3. Such lamps may be connected in a circuit in which they start and run with preheating of the cathodes; only T5-type HE according IEC 60081 sheet 6520 (14 W), sheet 6530 (21 W), sheet 6640 (28 W), sheet 6650 (35 W), T8, T10, or T12 lamps shall be used.
- d) For Level of Protection “eb” or “ec”, tungsten filament lamps in accordance with IEC 60064 and IEC 60432-1.
- e) For Level of Protection “eb”, a tungsten-halogen lamp in accordance with IEC 60432-2, restricted to max. 100 W
- f) For Level of Protection “ec”, a tungsten-halogen lamp in accordance with IEC 60432-2.
- g) For Level of Protection “ec”, a discharge lamp in accordance with IEC 62035.

NOTE It is not a requirement of this standard that conformity to the lamp type specification be verified.

5.3.2.3 Lamps for rated voltages not greater than 50 V

In addition to those lamps permitted by 5.3.2.2, the following are also permitted:

- Tungsten-halogen lamps with additional outer bulb in accordance with IEC 60432-3 with screw lampholder with minimum size of E14 in accordance with IEC 60061-1; or
- Tungsten-halogen lamps without additional outer bulb in accordance with IEC 60432-3 and with screw lamp cap with minimum size of E10 in accordance with IEC 60061-1.

5.3.2.4 Lamps for rated voltages not greater than 12 V

In addition to those lamps permitted by 5.3.2.2 or 5.3.2.3, the following are also permitted:

- Tungsten filament lamps with screw lamp cap with minimum size of E10 in accordance with IEC 60061-1;
- Tungsten filament lamps in accordance with IEC 60432-1 with bayonet lamp cap B15d / BA15d in accordance with IEC 60061-1; or
- Tungsten-halogen lamps with additional outer bulb in accordance with IEC 60432-3 and with bayonet lamp cap B15d / BA15d in accordance with IEC 60061-1.

5.3.2.5 Light Emitting Diodes (LED)

LEDs and combination of LEDs such as LED packages and LED modules shall be permitted for Level of Protection “ec”. The external electrical spacings shall comply with 0.

NOTE LEDs and combination of LEDs such as LED packages and LED modules are not currently a permitted light source for Level of Protection “eb” as these semiconductor devices are not yet considered to be sufficiently defined (with respect to the frequency and mode of failure) and therefore would require protection by another suitable type of protection.

5.3.3 Minimum distance between lamp and protective cover

For fluorescent tubes, the distance between the lamp and a protective cover shall be not less than 5 mm unless the protective cover is a concentric cylindrical tube, in which case the minimum distance is 2 mm.

For other lamps, the distance between the lamp and the protective cover shall be not less than the value given in Table 8, according to the lamp wattage.

Table 8 – Minimum distance between lamp and protective cover

Lamp wattage, P W	Minimum distance mm	
	Level of Protection “eb”	Level of protection “ec”
$P \leq 10$	1	1
$10 < P \leq 60$	3	3
$60 < P \leq 100$	5	5
$100 < P \leq 200$	10	7,5
$200 < P \leq 500$	20	10
$500 < P$	30	20

5.3.4 Electrical spacings

5.3.4.1 General

For luminaires in Level of Protection “eb”, all electrical spacings shall conform to the requirements of 4.3 and 4.4, except for those of the lamp and the internal parts of the screw or bayonet lampholders at the contact with the lamp.

For luminaires in Level of Protection “ec”, with exception of the field wiring terminals for which the creepage and clearance of 4.3 and 4.4 apply, the creepage distance and clearance requirements of the relevant clause of IEC 60598 are not changed.

5.3.4.2 Creepage distances and clearances at peak values of pulse voltages greater than 1,5 kV

Where circuits include ignitors that can subject lamps, lampholders and other components to high-voltage impulses in excess of 1,5 kV peak, the relevant minimum creepage distances and clearances shall conform to Table 9.

Table 9 – Creepage distances and clearances at peak values of pulse voltages greater than 1,5 kV

Part	Peak pulse voltages V_{pk}			
	kV	kV	kV	kV
	Above 1,5 and up to 2,8	Above 2,8 and up to 5,0	Above 1,5 and up to 2,8	Above 2,8 and up to 5,0
	Creepage mm		Clearances mm	
Lamp cap	4	6	4	6
Inside parts of lampholders	6	9	4	6
External parts of lampholders	8	12	6	9
Other built-in components ^a that are subject to the pulsed voltage of the ignitor	8	12	6	9

^a Unless the component itself is an encapsulated device or a sealed device.

5.3.4.3 Light Emitting Diodes (LEDs) for Level of Protection “ec”

The internal electrical spacings through the insulating material of each LED package need not comply with Clause 4. However, the external electrical spacings shall comply with Clause 4.

If type of protection “i” is employed for the driver circuitry to permit reduced external electrical spacings, the driver circuitry shall be evaluated as associated intrinsically safe apparatus and the single LEDs or LED array shall be evaluated as intrinsically safe apparatus in accordance with IEC 60079-11.

NOTE 1 There is a potential risk of ignition from optical radiation. Further guidance can be found in IEC 60079-28.

NOTE 2 Additional information is given in Annex J.

5.3.5 Lampholders and lamp caps

5.3.5.1 General

Lampholders, as far as applicable, shall conform to the safety and interchangeability requirements of the relevant industrial standard.

Plastics materials used for Level of Protection “eb” lampholders shall conform to the requirements of 4.6.

Plastics materials used for “ec” lampholders shall conform to the requirements of 4.6.2.

NOTE Normal operation does not include, for Level of Protection “ec”, the removal and insertion of lamps when their circuits are energized.

5.3.5.2 Screw lampholders and lamp caps

5.3.5.2.1 General

Where a screw-type lampholder is used, the centre contact of the lampholder shall be connected directly or indirectly to the live terminal of the supply connection in the luminaire.

5.3.5.2.2 Screw lampholders and lamp caps in Level of Protection “eb”

Unless the removal or inserting is intended to be made only outside the hazardous area as indicated by 9.4 i), screw lampholders together with the appropriate lamp caps shall conform to the test requirements for non-transmission of an internal ignition of IEC 60079-1 for Equipment Group I or Equipment Group II, as appropriate, both when inserted and at the

moment of making or breaking of the electrical contact, or the electrical contact between the lampholder and the lamp cap shall be such that on insertion or removal of the lamp cap, the making or breaking of the current occurs only in a separate enclosure complying with the constructional and test requirements of Equipment Group I or Equipment Group II of IEC 60079-1, as appropriate.

Screw lampholders shall be designed to avoid self-loosening of the lamp after insertion. For lamp caps other than E10, this shall be shown by meeting the mechanical test of 6.3.3.

At the moment of contact separation during unscrewing of the lamp, at least two complete threads shall be engaged.

Screw lampholders and lamp caps provided as part of a luminaire need not conform to the requirements of 4.4.2 and 4.3 if they conform to the minimum requirements for creepage distances and clearances in Table 10.

NOTE The insulating material of the lamp cap typically conforms to material group I in Table 1.

Table 10 – Creepage distances and clearances for screw lampholder and lamp cap

Voltage, U V	Creepage distance and clearance mm
$U \leq 10$	1
$10 < U \leq 63$	2
$63 < U \leq 250$	3
<p>When determining the required values for creepage and clearance, the voltage value in the table may be increased by a factor of 1,1 in order to recognize the range of rated voltages in common use.</p> <p>The creepage distance and clearance values shown are based on a maximum supply voltage tolerance of $\pm 10\%$.</p> <p>At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group I may be acceptable.</p>	

5.3.5.2.3 Screw lampholders for screw lamp caps in Level of Protection “ec”

Screw lampholders specified for use in the luminaire shall be one of the non-switched types according to IEC 60238.

NOTE It is not a requirement of this standard that conformity to the lampholder type specification, according to IEC 60238, be verified.

Screw lampholders shall prevent self-loosening of the lamp after insertion. For lamp caps other than E10, this shall be shown by meeting the mechanical test of 6.3.3. The spring elements used shall ensure a contact force of at least 10 N between lamp cap and lampholder. Screw lampholders and screw lamp caps provided as part of a luminaire need not conform to the requirements of 4.4.2 and 4.3 if they conform to the minimum requirements for creepage distances and clearances in Table 10.

5.3.5.3 Lampholders for bi pin lamps

5.3.5.3.1 General

The maximum values for torque and/or force at each end of the lamp occurring when fitting or removing the lamp in the luminaire shall be, for Level of Protection “eb” not more than 50 % and for Level of Protection “ec” not more than 75 %, of the limit values for unused lamps that may be applied to the pins of the lamp specified in IEC 61195.

The mechanical dimensions and the mounting conditions in the luminaire shall take into account the mechanical values and the tolerances for the lamp specifications according to IEC 60061-1 and IEC 61195.

NOTE 1: It is not a requirement of this standard that conformity to the lamp specifications, according to IEC 60061-1 and IEC 61195 be verified.

Bipin lampholders specified for use in the luminaire shall be G5 or G13 according to IEC 60400.

NOTE 2: It is not a requirement of this standard that conformity to the lampholder type specification, according to IEC 60400, be verified.

5.3.5.3.2 Lampholders for bi-pin lamps in Level of Protection “eb”

Lampholders for bi-pin lamps shall conform to the following requirements when mounted in the luminaire.

- a) The two pins on each lamp cap shall be connected in parallel, either within the lampholder, or directly adjacent within the luminaire wiring. The current-carrying capacity of each single pin connection shall be rated for the whole current of the lamp, to achieve redundancy.
- b) The electrical contact system for each lamp pin shall be independent of the presence of the other pin.
- c) The pins of the lamp shall be supported in a manner that minimizes distortion when they are subject to contact side pressure.
- d) The electrical contact between each pin of the lamp and the lampholder shall be reliable even under corrosion and vibration conditions. The type tests are given in 6.3.5 and 6.3.6.

5.3.5.3.3 Lampholders for bi-pin lamps in Level of Protection “ec”

In addition to the general industrial requirements, they shall also be designed to make and maintain contact on the barrels of the lamp pins. Contact pressures shall be adequate and the pins of the lamp shall be supported to prevent distortion when they are subject to contact side pressure.

5.3.5.4 Other lampholders and lamp caps

5.3.5.4.1 Single pin lampholder and lamp caps in Level of Protection “eb”

The enclosure formed by the lampholder and the lamp cap, both when inserted and at the moment of making or breaking of the electrical contact, shall conform to the test requirements for non-transmission of an internal ignition of IEC 60079-1 for Equipment Group I or Equipment Group II, as appropriate.

Lampholders and lamp caps, which together after mounting provide a suitable type of protection are also permitted

Lampholders for these tubular fluorescent lamps shall be type Fa6 of IEC 60061-2.

NOTE It is not a requirement of this standard that conformity to the lampholder type specification, according to IEC 60061-2, be verified.

5.3.5.4.2 Bayonet lamp holders

Bayonet lampholders specified for use in the luminaire shall be of the type according to IEC 61184.

NOTE It is not a requirement of this standard that conformity to the lampholder type specification, according to IEC 61184, be verified.

Bayonet lampholders shall incorporate spring contacts so designed that the springs are not the principal means of carrying the current. The connecting wires and their insulation shall not be subject to damage when the lamp is inserted or removed. The spring elements used shall ensure a contact force of at least 10 N between lamp cap and lampholder.

Bayonet lampholders in Level of Protection “eb” shall only be used for a rated voltage not greater than 12 V and a rated current not greater than 4 A.

5.3.5.5 Requirements for electrical contact between the lampholder and lamp cap in Level of Protection “eb”

The electrical contact to the lamp cap shall be:

- a) in the case of screw caps:
 - to the bottom contact of the lamp cap through resilient or spring contact elements with a force of at least 15 N when tested in accordance with 6.4.4.1, and
 - to the lamp cap through at least two threads or through one or more spring elements with a minimum removal torque prescribed in Table 15 when tested in accordance with 6.4.4.2;
- b) in the case of cylindrical pin caps through spring elements having a contact force of at least 10 N;
- c) in the case of cylindrical plug-in caps, where the design shall not allow electrical sparking in or external to the joint between the cap and holder, through spring elements having a contact force of at least 10 N;
- d) in the case of caps where, on removal from the respective lampholder, the circuit is interrupted in a separate flameproof enclosure (complying with IEC 60079-1) in such a way that the contact force exerted by the spring elements on the caps is not less than 7,5 N at the moment of circuit interruption;
- e) in the case of bayonet lampholders, the spring elements used shall ensure a contact force of at least 10 N between lamp cap and lampholder.

The above minimum values prescribed for the contact force apply with the lamp fitted to the holder and ready for use.

5.3.6 Auxiliaries for Luminaires in Level of Protection “ec”

5.3.6.1 Glow-type starters

Glow-type starters shall be of the type in which the contacts are enclosed in a hermetically sealed envelope (for example, glass bottle inside a metal or plastic enclosure; the enclosure does not have to be hermetically sealed).

5.3.6.2 Electronic starters and ignitors

Electronic starters and ignitors shall have a starting pulse voltage not exceeding 5 kV and shall be tested in accordance with 6.3.9. Creepage and clearances shall meet the requirements of Table 9. If the case is made of metal, it shall be bonded to the earth terminal of the luminaire. Electronic starters and ignitors that are sealed, potted or moulded in a case shall additionally conform to the relevant requirements of Level of Protection “mc”.

Circuits which include ignitors that subject internal wiring to high-voltage impulses shall be chosen so that the insulation is satisfactory for such impulses, shall meet the electric strength test of 6.3.7.

5.3.6.3 Starter holders

Contacts shall be resilient and shall provide adequate contact pressure. Compliance shall be checked by the test specified in 6.3.9.

5.3.6.4 Ballasts

Electromagnetic ballasts which are used with ignitors that have a working voltage above 1,5 kV shall not be of the type which can only be used with ignitors having a timed cut-out.

Electromagnetic ballasts subjected to only the 30 day voltage impulse type test shall only be used with timed cut-out ignitors.

If ignitors without timed cut-out are used, the 60 day voltage impulse test procedure based on product standard shall be used.

When conducting the tests to determine maximum surface temperature, the malfunctions to be considered are those defined as the “abnormal conditions” in the general industrial standards for electronic ballasts.

IEC 61347-1 permits certain exemptions to electrical spacings under conditions which are not acceptable for Level of Protection “ec” without further protection. If those reduced electrical spacings are employed, the ballast shall be protected by an internal over current device on the circuit board. However, the electrical spacings, within the ballast, on the supply side of the over current device shall be in line with 4.3 and 4.4. The over current device, if employed, shall have a rated voltage not less than that of the circuit and shall have a breaking capacity of at least 1,5 kA.

NOTE 1 The relevant industrial standard for electronic ballasts is IEC 61347-1.

NOTE 2 The rating of the fuse is normally selected based on the current of the ballast in normal operation, but is sometimes increased due to inrush impulses or transients due to EMC protection devices.

5.3.7 Surface temperatures

5.3.7.1 Luminaires

Under both normal, and in case of Level of Protection “eb”, at expected malfunctions or in case of Level of Protection “ec” at regular expected occurrences, the surface temperature of any internal part of the luminaire, or the external surface of the luminaire, shall not exceed the marked temperature class when tested in accordance with 6.3.4.

5.3.7.2 Lamp

The maximum surface temperature of the lamp may exceed the temperature class if the small component exemptions of IEC 60079-0 are applied.

However, even for lamp surfaces with an area greater than 1 000 mm², the maximum surface temperature normally permitted based on the auto-ignition temperature of the specific gas atmosphere may be exceeded if the highest surface temperature of the lamp surface inside the luminaire is at least 50 K below the auto-ignition temperature of the specific explosive gas atmosphere for which the luminaire is intended. This shall be determined by tests made in the most easily ignitable concentration of the specific explosive gas atmosphere. No ignition of the surrounding atmosphere shall occur. This dispensation is only valid for the specific explosive gas atmospheres indicated in the marking.

NOTE Measurements on existing luminaires employing lamps with convex glass outer envelopes have established that the surface temperatures of the lamp at which ignition will occur inside the luminaires are considerably higher than the auto-ignition temperatures shown in IEC 60079-20-1 for the same gas.

5.3.7.3 LEDs

As the photon emissions can affect thermocouple readings, care should be taken when temperature measurements are made inside of the focused light emission region. Maximum surface temperature determination shall be done using one of the following methods:

- a) an indirect method, by measuring the solder point and then calculating the junction temperature which is then used as the surface temperature of the LED;
- b) thermocouple method involving [copper – constantan], no larger than 0.1 mm diameter, adhered with a small drop of silicone adhesive in accordance with the adhesive manufacturer’s instructions for application and curing;

- c) thermocouple method involving shielded [iron – constantan] or [chromel – alumel] thermocouples adhered with a small drop of silicone adhesive in accordance with the adhesive manufacturer's instructions for application and curing.

NOTE The effect of irradiation on thermocouples can result in temperature measurements that are higher than the actual temperature of the surface being measured if the thermocouples are not shielded from the direct effect of such irradiation.

5.3.7.4 Temperature of lamp caps for tungsten-filament and tungsten-halogen lamps

The temperature at the rim of the lamp cap and at the soldering point of the lamp cap shall not exceed the limiting temperature. The limiting temperature is the lesser of 195 °C or the value specified in 4.8.

5.3.8 Limiting temperatures

The limiting temperature of ballasts, lampholders and lamps shall not be exceeded even in the case of ageing lamps. The luminaire shall be subjected to the type test of 6.3.4. The stabilized temperature of the ballast, lampholder, and the lamp itself shall be less than the limiting temperature, or a cut-off device shall be used to switch off the power before the limiting temperature is exceeded. Resetting of the cut-off device shall only be possible manually (e.g. by switching off the power for resetting).

5.3.9 Luminaires for tubular fluorescent bi-pin lamps

5.3.9.1 General

Luminaires for tubular fluorescent bi-pin lamps shall additionally conform to the following requirements.

5.3.9.2 Maximum ambient temperature

The maximum ambient temperature for a luminaire with tubular fluorescent bi-pin lamps employing electronic ballast shall not exceed 60 °C.

NOTE This limitation is to achieve a specific temperature class even under the end-of-life conditions for the lamp.

5.3.9.3 Temperature class

As the limiting temperature of a luminaire with tubular fluorescent bi-pin lamps employing an electronic ballast will exceed the temperatures appropriate for temperature classes T5 and T6, those temperature classes shall not be permitted. See 6.3.4.3.

5.3.9.4 Disconnection device

If a device which automatically disconnects all poles of the lampholder is provided in accordance with IEC 60079-0, it shall de-energize each lampholder when the protective cover is removed. When such a device is provided:

- a) the device shall be specified as an isolator in accordance with IEC 60947-1 and IEC 60664-1, overvoltage category III, or the contact clearance in the neutral and/or the supply lines shall be at least 2,5 mm each for a maximum supply voltage of 300 V (d.c. or r.m.s.) to achieve the clearance of 2,5 mm, two separate clearances of at least 1,25 mm each may be added together;
- b) the contacts shall open upon removal of the protective cover of the luminaire;
- c) the device and its operation shall not be capable of being readily defeated without the use of a tool;

NOTE One solution might be IP2X protection according to IEC 60529 of the operating part of the device. Another solution might be that the device can only be closed (after operating) by means of a tool.

- d) the device shall be protected using a suitable type of protection.

If a disconnection device is not provided, the luminaire shall be marked per item c) of Table 19 to indicate that the luminaire is not to be opened when energized.

5.3.9.5 Starting voltage for Level of Protection “eb” lamps

If an enhanced voltage is used to initiate discharge within the lamp (for example from an electronic starter/ignitor), the peak value of that voltage divided by $\sqrt{2}$ shall be used to determine the r.m.s. value used in Table 2. The metal ring of the lamp tube shall be assumed to be at the electrical potential of the pins.

If a device within the electronic ballast ensures that starting impulses will be stopped after a maximum time period of 5 s and that a reset is only possible after switching off the supply of the luminaire, then the factor $\sqrt{2}$ may be increased to 2,3.

5.3.9.6 Starting voltage for Level of Protection “ec” lamps

If an enhanced voltage is used to initiate discharge within the lamp (for example from an electronic starter/ignitor), the peak value of that voltage divided by 2 shall be used to determine the r.m.s. value used in Table 2. The metal ring of the lamp tube shall be assumed to be at the electrical potential of the pins.

If a device within the electronic ballast ensures that starting impulses will be stopped after a maximum time period of 5 s and that a reset is only possible after switching off the supply of the luminaire, then the factor 2 may be increased to 3. As the minimum the supply voltage is to be used.

5.3.10 Tests for resistance to impact

For all luminaires intended for fixed installation, the tests for resistance to impact of IEC 60079-0 apply.

For portable and transportable luminaires and handlights the tests for resistance to impact in IEC 60079-0 are modified as shown in 6.3.2.2.

5.4 Analog measuring instruments and instrument transformers

5.4.1 General

The requirements of 5.4.2 through 5.4.7 apply to analog measuring instruments and instrument transformers in Level of Protection “eb”.

The requirements of 5.4.7 apply to analog measuring instruments and instrument transformers in Level of Protection “ec”.

5.4.2 Limiting temperature

Analog measuring instruments and instrument transformers shall be able to withstand continuously 1,2 times their rated current and/or their rated voltage, as appropriate, without exceeding the limiting temperatures according to 4.8.

Terminals used in conjunction with measuring instruments and instrument transformers are evaluated based on 1,1 times their rated current and are not permitted to exceed the limiting temperature according to 4.8 at that current.

5.4.3 Short-circuit currents

Current transformers and the current-carrying parts of analog measuring instruments (excluding voltage circuits) shall be able to withstand thermal and dynamic stresses resulting

from currents equal to at least the values stated in Table 11 for the periods as indicated in 6.4 with no reduction in their level of security against explosions.

Table 11 – Resistance to the effect of short-circuit currents

Current	Current transformer and current-carrying parts of analog measuring instruments
I_{th}	$\geq 1,1 \times I_{sc}$ (see 3.14 and Note 2)
I_{dyn}	$\geq 1,25 \times 2,5 I_{sc}$ (see Notes 1 and 2)
NOTE 1 $2,5 I_{sc}$ is the maximum peak value of the short-circuit current.	
NOTE 2 Factors 1,1 and 1,25 are safety factors. It follows that the r.m.s. value of the permissible short-circuit current in service may not exceed $I_{th}/1,1$ and its peak value may not exceed $I_{dyn}/1,25$.	

5.4.4 Short time thermal current

The temperature attained during the passage of a current equal to the rated short-time thermal current I_{th} shall not exceed the limiting temperature specified in 4.8 and in no case shall it exceed 200 °C.

5.4.5 Measuring instruments supplied by current transformers

Where the current-carrying parts of analog measuring instruments are supplied by current transformers, the values of I_{th} and I_{dyn} need only equal the current flowing in the short-circuited secondary windings of the current transformer with its primary windings carrying the currents I_{th} and I_{dyn} applicable to them.

5.4.6 Moving coils

Analog measuring instruments with moving coils are not permitted.

5.4.7 External secondary circuits

If the secondary circuit of the current transformer extends outside the equipment, the certificate number shall include the "X" suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the need to guard against the secondary circuit becoming open-circuited in service.

If current transformers are fitted, under open-circuit secondary conditions they can be capable of producing voltages which are significantly in excess of the voltage rating of the terminals employed in the current transformer circuit. Dependent upon the circumstances of a particular installation, it might be appropriate to take precautions to ensure that dangerous voltages associated with open-circuits cannot occur.

For equipment having current transformers connected to matching transformers in the switchgear (for example a differential protection system), consideration should be given to the effect at the equipment of any possible disconnection of either set of transformers.

5.5 Transformers other than instrument transformers

Transformers other than instrument transformers for which the requirements are given in 5.4 shall be tested in accordance with 6.5.

5.6 Supplementary requirements for equipment incorporating cells and batteries

5.6.1 Type of cells and batteries

5.6.1.1 General

Cells and batteries are differentiated according to the construction and the likelihood of the evolution of electrolytic gases (for example, hydrogen and/or oxygen). This standard places restrictions on the use of cells and batteries according to their type, see Table 12.

Some cells and batteries are, by design, a specific type, i.e. sealed cells, valve-regulated cells or batteries, or vented cells or batteries. For cells and batteries that are valve-regulated by design, they may be able to be applied as if they were sealed in the end-application if abnormal conditions that could cause venting are avoided.

NOTE 1 Examples of such abnormal conditions to consider include:

- 1) Abnormal ambient conditions, including high ambient storage or use, and extreme low ambient charging.
- 2) Abnormal charging conditions, including excessive charging or overcharging rate, and extended overcharging.
- 3) Abnormal discharging conditions, including deep discharging.
- 4) Abnormal battery/charger combinations due to incompatible charging issues.

For cells and batteries that are vented by design, they cannot be considered any other type.

NOTE 2 In general, Nickel-cadmium and Nickel metal hydride cells and batteries are not, by design, always any one specific type

NOTE 3 IEC 60079-0 includes standard atmospheric conditions that may be exceeded unintentionally should cells or batteries, of any type, vent into a well-sealed enclosure resulting in an elevated pressure flammable mixture with elevated oxygen content. This can occur when the volume of the battery or cell represents a high percentage of the volume of the enclosure a situation commonly occurring in equipment such as hand-held torches. A pressure relief vent is often used to maintain the internal pressure within the limits of the standard atmospheric conditions of IEC 60079-0.

5.6.1.2 Sealed cells

This includes sealed primary cells and sealed secondary cells where the operating parameters are within the manufacturer's recommended limits and any required safety devices are either part of the equipment, or the requirements for them are defined in the equipment documentation in such a way as to give equivalent protection against abnormal conditions that could cause venting. The maximum capacity is 25 Ah.

These types of cells or batteries constructed from these cells may be used in Level of Protection "ec" equipment without additional precautions. The maximum capacity is 25 Ah for either cells or batteries.

The technical requirements and special precautions for Level of Protection "eb" are given in 5.6.2 and 5.6.4 and the verification and tests in 6.6.

5.6.1.3 Valve-regulated cells and batteries

When these valve-regulated cells are applied in Level of Protection "eb" equipment, the cell's limits and control system shall be fully specified.

When the cell's recommended limits and the control system are not fully specified in accordance with the cell requirements, they may be used in Level of Protection "ec" equipment which does not contain parts which in normal operation produce arcs or sparks. It is, however, acceptable to incorporate these cells or batteries in such equipment provided that they are in a separate compartment in the equipment, vented directly to the atmosphere external to the enclosure. When using these cells or batteries special precautions shall be taken into account.

The technical requirements and special precautions are given in 5.6.2, 5.6.2.11, and 5.6.4 and the verification and tests are given in 6.6.

5.6.1.4 Vented cells and batteries

These types of cells and batteries shall be designed to avoid accumulation of gas in the compartments by venting them to the atmosphere external to the enclosure. The compartments shall contain no other electrical parts employing Type of Protection “e”, except those necessary to make the connections to the cells and batteries.

The technical requirements and special precautions are given in 5.6.2, 5.6.2.11, and 5.6.4 and the verification and tests are given in 6.6.

Table 12 – Types and use of cells and batteries

Type of cell or battery	Capacity of cell or battery	Permitted activity in hazardous area			Remarks
		Discharging	Charging of secondary cells	Additional equipment in the same compartment	
sealed	≤ 25 Ah	Yes	Yes	Yes	–
valve-regulated	No restriction	Yes	No ^a	Yes Only “e” “m” with “e” connections “o” with “e” connections	Equipment with Type of Protection “d”, “i” or “q” shall be located in a separate compartment and their integral connections shall not be in same compartment as the battery
vented	No restriction	Yes	No ^a	No	–

^a For charging in hazardous areas, special precautions are required.

5.6.2 Requirements for cells and batteries ≤25 Ah

5.6.2.1 Encapsulation of cells or batteries

Where cells or batteries are subject to encapsulation, care shall be taken to ensure that any pressure relief facilities are not obstructed. The vent size shall be sufficiently large to prevent dangerous pressurization of the encapsulated assembly at the most onerous predictable release rate from the battery. A minimum of one vent for each cell is required.

If the encapsulation of cells or batteries is used to maintain the type of protection, the encapsulation shall allow for possible expansion of the cells during charging.

NOTE 1 For the purpose of this standard, the terms 'encapsulate' and 'encapsulation' do not imply conformity with IEC 60079-18.

NOTE 2 The physical characteristic of vents will depend upon the type and capacity of the battery arrangements. The effects of ageing on battery capacity can affect the rate of gas evolution from the battery.

5.6.2.2 Use of secondary cells or batteries

Secondary cells or batteries shall not be used in equipment designed for primary cells or batteries or vice versa unless the equipment is designed specifically for use with both.

5.6.2.3 Cell connection

Batteries for Level of Protection “eb” shall be made only of cells connected in series. Batteries for Level of Protection “ec” shall be made of cells connected in series except for the specific

case where two cells are permitted to be connected in parallel with no further cells connected in series.

5.6.2.4 Discharge mode

5.6.2.4.1 General

5.6.2.4.1.1 Connecting cells in series

No more than three sealed cells or valve-regulated cells shall be connected in series, unless precautions are taken to prevent reverse charging.

NOTE The actual capacity of a cell might be reduced with time. If this occurs, cells of higher actual capacity can cause cells of lower capacity to reverse.

5.6.2.4.1.2 Deep discharge protection

If a deep discharge protection is installed to prevent reverse charging of cells, the minimum cut-off voltage shall conform to the cell manufacturer's specification. For Level of Protection "eb", the current in amperes from the battery after switching off the load shall be less than 0,1 % of the rated capacity in Ah.

NOTE Generally, a maximum of six cells can be protected by one deep discharge protection circuit. If too many cells are connected in series, there might be no safe protection due to the tolerances of individual cell voltages and of the deep discharge protection circuit.

5.6.2.4.2 Discharge conditions for Level of Protection "eb"

Where a load current drawn from an Ex Component cell or battery can cause such damage to the battery as to invalidate the type of protection increased safety, the load or safety device shall be specified by the manufacturer. Where the type of protection increased safety is not invalidated, the load need not be specified or safety device provided.

NOTE 1 Specifying the permitted load is only practical for an Ex Component battery as a battery supplied as part of equipment will need to be capable of supplying the connected load of the equipment without invalidating the type of protection increased safety.

For verification and tests of the maximum surface temperature rating, the highest discharge current permitted by the maximum load specified by the manufacturer or by the protection device shall be taken into account, for example $1,7 \times$ rating of the fuse, or at short-circuit if neither load nor protection device is specified.

The safety devices required by this standard form safety related parts of a control system. It is the responsibility of the manufacturer to assess that the safety integrity of the control system is consistent with the level of safety required by this standard.

NOTE 2 Safety related parts meeting the requirements of category PL c of ISO 13849-1 would satisfy the above.

5.6.2.4.3 Discharge conditions for Level of Protection "ec"

Cells and batteries in discharge mode shall be used as specified by the cell or battery manufacturer. For verification and test of the temperature rating, the highest discharge current in normal operation shall be taken into account. If during discharging an excessive load drawn from the cell or battery can cause damage to the cell or battery affecting the Level of Protection "ec", the maximum load or a safety device shall be specified.

5.6.2.5 Service temperature

The service temperature of the cell or battery shall not exceed the value specified by the manufacturer.

5.6.2.6 Creepage and clearance

5.6.2.6.1 Level of Protection “eb”

The electrical connections between cells and to batteries shall conform to 4.2 and shall be of a type recommended by the manufacturer of the cell or battery.

The following clearance and creepage distances shall apply between the cell poles.

- a) For an inherently safe single cell, that is where the short-circuit current and maximum surface temperature are limited to a suitable value by its internal resistance, the clearance and creepage distances between the cell poles may be ignored.
- b) For a single cell, with a maximum open-circuit voltage of 2 V or less, not forming part of a battery, the clearance and creepage distances between the cell poles shall be not less than 0,5 mm.
- c) For batteries where the battery voltage does not exceed 10 V, and both the cells and inter-cell connections are fixed, no additional creepage and clearance distances between the cells are required. The creepage and clearance distances for the external terminals of a battery shall be as given in Table 2.
- d) For all other batteries and for all cells having a voltage exceeding 2 V, the clearance and creepage distances shall be those appropriate for the voltage, as given in Table 2.

5.6.2.6.2 Level of Protection “ec”

Creepage and clearance distances between the poles of a cell shall be in accordance with the relevant industrial standards for cells and batteries.

5.6.2.7 Connections

The electrical connections between cells and batteries shall conform to 4.2 and be of a type recommended by the manufacturer of the cell or battery to ensure there is no excessive stress to the cell or battery.

5.6.2.8 Replaceable battery packs

Cells or batteries shall be securely connected when assembled as a replaceable battery-pack.

NOTE This reduces the likelihood of faulty connections, connections of cells with different status of charge or different age.

5.6.2.9 Replaceable battery pack connections

If cells and batteries do not form an integral part of the equipment, precautions shall be taken to safeguard against incorrect connection between cells or the battery with the equipment and charger. Suitable precautions include polarized connectors, or those which are clearly marked to indicate correct assembly. Provision shall also be made for safe interconnection of the circuit.

5.6.2.10 Release of electrolyte

5.6.2.10.1 Level of Protection “eb”

If there is a risk of electrolyte being released from cells under normal or single malfunction conditions, provision shall be made to prevent contamination of live parts. There is no need for protection for sealed cells and batteries. Vented cells or valve-regulated cells or batteries shall be enclosed in a separate compartment to avoid electrolyte which may be released from the cell causing contamination to other parts of the equipment. Additionally, for these types of cells or batteries, the creepage and clearance values inside the cell or battery compartment needs to be at least 10 mm.

5.6.2.10.2 Level of Protection “ec”

If electrolyte can be released from cells as a normal occurrence, provision shall be made to mitigate contamination of live parts. Sealed cells or valve-regulated cells do not need additional protection.

5.6.2.11 Disconnection and transportation

If a battery in Level of Protection “eb” has to be disconnected in the hazardous area then it shall be capable of being disconnected safely. Unless the live parts are protected to at least IP30, the cells and batteries shall be marked as shown in item e) of Table 19 to warn that they shall not be taken through the hazardous area.

5.6.3 Requirements for valve-regulated or vented cells or batteries >25 Ah

5.6.3.1 Types of permissible batteries

Vented batteries shall be of the lead-acid, nickel-iron, nickel-metal hydrides or nickel-cadmium type. The capacity of vented batteries is not restricted. For liquid filled monobloc batteries, typically used for internal combustion engine starting or small standby applications, the relevant clauses and design principles shall be applied but connection arrangements can be appropriate to the method of construction in a unit.

The tests and verification are given in 6.6.

5.6.3.2 Battery containers

5.6.3.2.1 Internal surfaces

Internal surfaces shall not be adversely affected by the action of the electrolyte.

5.6.3.2.2 Mechanical requirements

Battery containers including covers shall be designed so as to withstand mechanical stress anticipated when in use, including that due to transportation and handling. In order to achieve this, it may be necessary to incorporate partition walls in the containers.

5.6.3.2.3 Creepage distances

5.6.3.2.3.1 Level of Protection “eb”

If necessary, battery containers shall be provided with insulating barriers. Partition walls may be accepted as insulating barriers, if suitably constructed. Insulating barriers shall be positioned so as to prevent the development of a nominal voltage exceeding 40 V in any section. The insulating barriers shall be constructed in such a manner that the required creepage distance in service will not be reduced. The height of the insulating barriers shall be at least two-thirds the height of the cells. The method indicated in Figure 1, examples 2 and 3, shall not be used in the calculations of these creepage distances.

The creepage distance between the poles of adjacent cells and between these poles and the battery container shall be at least 35 mm. Where nominal voltages between adjacent cells of the battery exceed 24 V, these creepage distances shall be increased by at least 1 mm for each 2 V in excess of 24 V.

5.6.3.2.3.2 Level of Protection “ec”

For battery containers that are metallic without an insulating barrier, the creepage distance between the poles of adjacent cells and between these poles and the battery container shall be at least 35 mm. For a non-metallic enclosure, the creepage distances shall conform to

Table 2. Where nominal voltages between adjacent cells of the battery exceed 24 V, these creepage distances shall be increased by at least 1 mm for every 2 V in excess of 24 V.

5.6.3.2.4 Cover

The cover of a battery container shall be fixed in such a way that any inadvertent opening or displacement, while in normal operation, is avoided.

5.6.3.2.5 Cell assembly

The cells shall be built into the battery containers in such a way that there is no significant displacement likely in service. The materials of terminal mountings and other built-in items (for example, packing and insulating barriers) shall be insulating, non-porous, and resistant to the action of the electrolyte.

5.6.3.2.6 Liquid extraction

The extraction of liquid, which may have entered battery containers that do not have drain holes, shall be possible without the removal of the cells.

5.6.3.2.7 Ventilation

The battery container shall be provided with adequate ventilation. As an exception to the limits for degrees of protection given in 4.10 for protection against the ingress of solid foreign bodies and water, a degree of protection of IP23 in accordance with IEC 60529 is sufficient for a battery container.

If a practical test for IPX3 according to IEC 60529 is carried out and if water enters the battery container, then the insulation resistance test as described in 6.6.2 may be used to judge a harmful amount.

5.6.3.2.8 Plugs and sockets

In addition to the requirements in IEC 60079-0, single-pole positive and negative plugs and sockets shall not be interchangeable.

5.6.3.2.9 Polarity marking

The polarity of the battery connections and of plugs and sockets shall be marked clearly in a durable manner.

5.6.3.2.10 Other equipment

Any other electrical equipment affixed to or incorporated in the battery container shall be suitable for the intended application.

5.6.3.2.11 Insulation resistance

New batteries, fully charged and ready for service, shall have an insulation resistance of at least 1 MΩ between the live parts and the battery container.

5.6.3.3 Cells

5.6.3.3.1 Lids

The cell lid shall be sealed to the cell container so as to prevent detachment of the cell lid and leakage of the electrolyte.

5.6.3.3.2 Support

The positive and negative plates shall be supported to restrict movement.

5.6.3.3.3 Electrolyte maintenance

Each cell requiring maintenance of the electrolyte level shall be provided with a means of indicating that the electrolyte level lies between the minimum and maximum permissible levels. Precautions shall be taken to avoid excessive corrosion of the plate lugs and the bus bars when the electrolyte is at the minimum level.

5.6.3.3.4 Expansion space

In each cell sufficient space shall be provided to prevent the cell overflowing due to expansion of the electrolyte and also for deposition of slurry where this is likely to occur. These spaces shall be related to the anticipated life of the battery.

5.6.3.3.5 Filling and vent plugs

Filling and vent plugs shall be designed to prevent any ejection of the electrolyte under normal conditions of use. They shall be located in such a manner that they are easily accessible for maintenance.

5.6.3.3.6 Electrolyte seals

A seal shall be provided between each pole and the lid of the cell to prevent leakage of the electrolyte.

5.6.3.4 Connections

5.6.3.4.1 Intercell connections

The intercell connectors between cells that can move relative to one another shall be non-rigid. When non-rigid connections are used, each end of the connection shall be:

- a) welded or soldered into the terminal post; or
- b) crimped into a copper sleeve cast into the terminal post; or
- c) crimped into a copper termination screwed by a threaded fastening to an insert cast into the cell terminal post. The insert may be copper or other materials if the mechanical and thermal/electrical properties of the connection are found acceptable by the bushing torque test of IEC 60079-0, and by satisfying the requirements of this subclause. The threaded joints shall be secured against loosening.

In cases b) and c), the conductor shall be copper. In case c), the effective contact area between the termination and the cell terminal post shall be at least equal to the conductor cross-section. In calculating the effective contact area, no account shall be taken of the area of male and female threads in contact.

Although the word 'copper' is used in item c) above, copper alloyed with a small amount of another metal (for example chromium or beryllium) is acceptable where it is necessary to improve the mechanical properties of the connection (for example to prevent stripping of screw threads in the copper insert). Where such alloys are used, it may be necessary to increase the contact area of the inter-cell connection to counteract any decrease in electrical conductivity caused by the other metal.

5.6.3.4.2 Temperature assessment

5.6.3.4.2.1 Level of Protection “eb”

The connectors shall be able to carry the current required for the duty without exceeding the limiting temperature (see 4.5, 4.8.1 and 4.8.2). Where the duty cannot be defined, the battery shall be assessed at the discharge rate used by the battery manufacturer to determine the battery capacity. Where double connectors are used, each single connector shall be capable of carrying the total current without exceeding the limiting temperature.

5.6.3.4.2.2 Level of Protection “ec”

The connectors and terminations shall be able to carry the current required for the application without exceeding the temperature class. Where the application is not specified, the battery shall be assessed at the 1 h discharge rate specified by the battery manufacturer.

5.6.3.4.3 Connector protection

All connectors exposed to attack by the electrolyte shall be suitably protected; for example, for lead-acid batteries, non-insulated connectors of metals other than lead shall be lead coated. This does not apply to screw threads.

Live parts shall have insulating protection to avoid accidental contact when the battery container cover is open.

5.6.4 Charging of cells and batteries

5.6.4.1 Charger specifications

5.6.4.1.1 Level of Protection “eb”

If the cells and batteries are intended to be recharged in hazardous areas, the charging circuits shall be fully specified as part of the equipment. The charging system shall be such that, even with a single malfunction in the charging system, the charger voltage and current do not exceed the limits specified by the manufacturer. No additional requirements apply to the charging of valve-regulated cells.

Charging is only permitted within the safety limits specified by the manufacturer.

If the transportation of batteries or cells in or into hazardous areas while charging is not permitted by the manufacturer, the product shall be marked with an “X” in accordance with IEC 60079-0 and the Specific Conditions of Use shall be shown on the Certificate. The equipment shall be marked as shown in item f) of Table 19 to warn that they shall not be charged in the hazardous area.

If the charger is an integral part of the equipment and is not protected by a suitable type of protection (intended only for use in a non-hazardous area) it will need to be de-energized and protected from reverse current caused by the cell or battery. If a time is required, for a charger that is not protected by a suitable type of protection, for the temperature of parts to cool below the limiting temperature, the equipment shall be marked as shown in item e) of Table 19 to warn that they shall not be transported into the hazardous area for ‘X’ minutes after completion of charging.

Where there is another voltage source in the same enclosure, the battery and its associated circuits shall be protected against charging by other than the circuit specifically designed to do so. For example, this may be achieved by separating the battery and its associated circuits from all other voltage source(s) inside the enclosure using the creepage and clearance distances specified in Table 2 for the highest voltage encountered.

5.6.4.1.2 Level of Protection “ec”

If cells and batteries which are an integral part of the electrical equipment are to be charged in the hazardous area, the charger shall be fully specified as part of the equipment design. The charging system shall be designed so that, in normal operation, the charge voltage and current do not exceed the limits specified by the manufacturer based on the service temperature range of the equipment.

5.6.4.2 Outgassing during charging of valve-regulated or vented cells or batteries

5.6.4.2.1 Level of Protection “eb”

For the charging of valve-regulated cells, the maximum concentration of hydrogen in the battery container shall not exceed 2 % by volume while continuously measured for the duration of the test described in 6.6.4 using the charging apparatus specified as part of the equipment.

5.6.4.2.2 Level of Protection “ec”

The charging system should not normally cause gassing. However, if gassing does occur, the construction of the battery container shall be such that the H₂ level in it shall not exceed 2 % V/V after 48 h. This shall be verified by the test of 6.7.4

NOTE These requirements do not apply to sealed cells which can be used in Level of Protection “ec” without any additional protection, see 5.6.1.2.

5.7 General purpose connection and junction boxes

General purpose connection and junction boxes shall be allocated a rating determined by the method in 6.7.4 to ensure that the limiting temperature of 4.8 is not exceeded in service.

The rating (see Annex E) shall be expressed as either:

- a) the rated maximum dissipated power; or
- b) the set of values comprising, for each terminal size, the permissible number and size of conductor and the maximum current.

Information on the use of the rating in determining safe combinations of terminals and conductor for particular values of current is given in Annex E.

5.8 Resistance heating equipment (other than trace heating systems)

5.8.1 General

This subclause specifies supplementary requirements for the resistance heating devices and resistance heating units (other than trace heating systems) defined in 3.13. It does not apply to induction heating, skin effect heating, dielectric heating or to any other heating system which involves passing current through a liquid, an enclosure or pipework. The requirements for the type tests are given in Clause 6.

NOTE 1 The requirements for trace heating systems are given in IEC 60079-30-1.

NOTE 2 Additional measures for increased safety have been applied to resistance heating by the required temperature limit device, sealed containment, residual current detection (30 mA to 100 mA) with an acceptable grounded housing or an insulation monitoring system, and thermal stability tests of the insulation system.

5.8.2 Heating resistors

Heating resistors are not considered to be windings and 4.7 does not apply.

The non-metallic material requirements of IEC 60079-0 do not apply to the electrical insulating materials of heating resistors.

NOTE For parts of a heating system which are not the heating resistor itself, 4.5 applies

5.8.3 Temperature coefficient

The heating resistor shall have a positive temperature coefficient. The manufacturer shall specify the value of the resistance at 20 °C and its tolerance.

5.8.4 Insulating material

The insulating materials used in a resistance heating device shall be tested in accordance with 6.9.

5.8.5 Cold-start current

The cold start current of the resistance heating device when tested in accordance with 6.9.5 shall not exceed the manufacturer's declared value by more than 10 % at any time after the first 10 s of energization.

5.8.6 Electrical safety device

5.8.6.1 General

The function of this protection, which is additional to the overcurrent protection, is to limit the heating effect and possible arcing due to abnormal earth fault and earth leakage currents. The manufacturer shall specify a safety device for use with each resistance heating device or unit. Unless the resistance heating device or unit is intended to be mechanically protected by the manner in which it is incorporated in electrical equipment, (for example an anti-condensation heater in an electric machine), the safety device shall comply with 5.8.6.2.

5.8.6.2 Method of protection

5.8.6.2.1 General

The method of protection will depend on the type of system earthing (see IEC 60364-5-55 for definitions).

5.8.6.2.2 TT and TN systems

A residual current operated safety device with a rated residual operating current not exceeding 100 mA is intended to be used at the time of installation.

NOTE 1 Preference is to be given to protective devices with a rated residual operating current of 30 mA. This protective device should have a maximum break time not exceeding 100 ms at the rated residual operating current.

NOTE 2 Typically, this system will disconnect all non-grounded phases at a residual operating current of 30 mA or higher.

NOTE 3 Additional information on residual current operated protective devices is given in IEC 61008-1.

5.8.6.2.3 IT system

An insulation monitoring device is intended to be installed at the time of installation to disconnect the supply whenever the insulation resistance is not greater than 50 Ω/V of rated voltage.

5.8.7 Electrically conductive covering

When an electrically conductive covering ensures the function of the protective device foreseen in 5.8.6, it shall extend over the whole of the surface of the insulating sheath and

consist of an evenly distributed conductive layer with a coverage of at least 70 % of the insulating surface. The electrical resistance of the conductive covering shall be sufficient to ensure operation of the protective device foreseen in 5.8.6.

5.8.8 Exclusion of explosive atmosphere

The electrical insulation shall ensure that the heating resistors cannot be in contact with the explosive atmosphere, unless the surface temperature is below the temperature class.

NOTE Beaded insulation would not satisfy this requirement.

For the determination of the temperature class of a resistance heating device in Level of Protection “eb”, any additional thermal insulation intended to be installed shall not normally be considered as excluding access of the explosive gas atmosphere.

5.8.9 Conductor cross-section

The cross-section of the conductors for connections to the resistance heating device shall be at least 1 mm² for mechanical reasons.

5.8.10 Limiting temperature

The resistance heating device or unit shall be prevented from exceeding the limiting temperature when energized.

This shall be ensured by one of the following means:

- a) a stabilized design using the temperature self-limiting characteristic of the resistance heating device;
- b) a stabilized design of a heating system (under specified conditions of use);
- c) a safety device according to 5.8.11 .

For b) and c), the temperature of a resistance heating device is dependent on the relationships between various parameters:

- its heat output;
- the temperature of its surroundings: gas, liquid, workpiece;
- the heat transfer characteristics between the resistance heating device and its surroundings.

The necessary data regarding these relationships shall be provided by the manufacturer in the documentation prepared in accordance with IEC 60079-0.

NOTE For b) and c), the temperature of a resistance heating device is dependent on the relationships between various parameters which can include, but is not limited to:

- ambient temperature range
- inlet and outlet temperature of the medium or temperature of the workpiece
- medium to be heated, with its physical properties (thermal conductivity, specific heat capacity, kinematic viscosity, Prandtl number, relative density)
- temperature class
- heat output
- heat flux, dependent on the physical properties of the medium, its flow velocity, the supply voltage and the permissible surface temperature
- geometry of the heating unit (arrangement of the individual heating elements, angle of incidence, heat transfer)

5.8.11 Safety device

The protection offered by a safety device shall be achieved by sensing:

- a) the temperature of the resistance heating device or, if appropriate, of its immediate surroundings;
- b) the temperature of the resistance heating device or the surrounding temperature; and one or more other parameters.

NOTE 1 Examples of such parameters include:

- in the case of liquids, a covering of the heating device of at least 50 mm can be ensured by means of a level monitor (dry run protection); or
- in the case of flowing media such as gas and air, the minimum throughput can be ensured by means of a flow monitor, or
- for the heating of workpieces, the heat transfer can be ensured by the fixing of the heating device or with auxiliary agents (heat-conducting cement).

Where Specific Conditions of Use are necessary, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail the restrictions of use. For example, when the resistance heating unit is supplied with a safety device that is intended to be connected to other devices, functioning together as a safety system, the selection and interconnection information of the associated equipment shall be detailed in the Specific Conditions of Use. Where additional information is necessary for the selection and installation of equipment functioning as part of the safety system, the details shall be included in the Instructions.

A reset shall only be possible by hand after the previously defined process conditions have returned, except when the information from the safety device is continuously monitored. In the event of failure of the sensor, the heating device shall be de-energized before the limiting temperature is reached. Resetting or replacement of a manually re-armed safety device shall be possible only with the aid of a tool.

The adjustment of the safety devices shall be locked and sealed and shall not be capable of being subsequently altered when in service.

NOTE 2 Thermal fuses are intended to be replaced only by parts specified by the manufacturer.

The safety device shall operate under the abnormal conditions and shall be additional to and functionally independent of any regulating device which may be necessary for operational reasons under the normal conditions.

For Level of Protection “eb”, the safety device shall de-energize the resistance heating device or unit either directly or indirectly.

For Level of Protection “ec”, the safety device shall:

- de-energize the resistance heating device or unit either directly or indirectly; or
- provide an output for an alarm intended to be located in a constantly attended location.

5.9 Supplementary requirements for fuses

5.9.1 General

Fuses are permitted to be used in Level of Protection “ec”. Only non-renewable types, applied within their ratings, are permitted as they are not considered to open in normal operation and become an arcing part.

NOTE 1 A non-renewable fuse is a fuse without a replaceable fuse element.

NOTE 2 For equipment in Level of Protection “eb” requiring a fuse for short circuit or thermal protection, the fuse is located outside the hazardous area or is protected by another type of protection suitable for EPL Gb. Level of Protection “eb” is only suitable for the connections to the fuse.

5.9.2 Temperature class of equipment

The maximum surface temperature of the equipment shall consider each fuse mounted in the equipment based on the normal current of the fuse in the specific application. The maximum surface temperature for the fuse shall be measured:

- for un-filled fuses, on the fuse element;
- for filled fuses on the surface of the fuse cartridge.

5.9.3 Fuse mounting

Fuses shall be mounted in enclosed holders or spring holders or shall be soldered in place. Fuse-to-fuse holder connections shall be in accordance with 4.2.3.5.

5.9.4 Fuse enclosures

Enclosures containing fuses shall be interlocked so that the fuses can only be removed or replaced with the supply disconnected. Alternatively, the enclosure shall carry the warning given in item h) of Table 19.

5.9.5 Replacement fuse identification

Unless the fuses are of a non-interchangeable type, provision shall be made for the correct type and value for replacement fuses to be marked adjacent to the fuse holders.

5.10 Other electrical equipment

Electrical equipment not completely defined in 5.2 to 5.9 shall conform to the constructional requirements in Clause 4 and the principles of the supplementary requirements in Clause 5.

The certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail:

- the concept, method and unique aspects applicable to the equipment;
- installation instructions including full connection details.

The documentation required by IEC 60079-0 shall include a full description of how the intent of this clause is satisfied.

NOTE 1 This subclause is intended to provide opportunities for the incorporation of new technology. The manufacturer is expected to conduct an analysis of potential faults of the equipment to ensure the required degree of safety during operation over the foreseeable life. This is normally based on equivalence to those increased degrees of safety achieved over normal industrial equipment as specified in this standard.

NOTE 2 IEC 60079-33, *Explosive atmospheres – Part 33: Special protection “s”* provides normative requirements that can be applied to these types of equipment. It is anticipated that IEC 60079-33 will replace the requirements of 5.10 as the method of evaluation for this type of equipment. A certification process is currently under development by IECEx.

6 Type verifications and type tests

6.1 Dielectric strength

Dielectric strength shall be verified by test:

- a) either as given in a relevant industrial standard for the individual items of electrical equipment; or
- b) if no such test requirement exists, at the test voltage according to 1), 2) or 3) below, and maintained for at least 1 min without dielectric breakdown occurring.

- 1) For electrical equipment and Ex Components with rated voltages not exceeding 90 V peak or in which working voltages not exceeding 90 V peak are present: 500 V r.m.s. $^{+5}_0$ %.
- 2) For resistance heating devices and resistance heating units to which additional requirements of 5.8 apply: $(1\,000 + 2U_n)$ V r.m.s. $^{+5}_0$ %, where U_n is the rated voltage.
- 3) For other electrical equipment and Ex Components, where working voltages exceeding 90 V peak are present: $(1\,000 + 2U)$ V r.m.s. $^{+5}_0$ % or 1 500 V r.m.s. $^{+5}_0$ %, whichever is greater, where U is the working voltage.

D.C. test voltages are permitted as an alternative to the specified a.c. test voltage and shall be 170 % of the specified a.c., r.m.s. test voltage for insulated windings, or 140 % of the specified a.c., r.m.s. test voltage for situations where air or creepage distance is the insulating medium.

For equipment or Ex Components with galvanically isolated parts, the test shall be applied separately, at the appropriate voltage, to each part.

Dielectric tests are not required when:

- the equipment contains only Ex Components, with connections complying with IEC 60079-7;
- there is no factory installed interconnecting wiring; and
- all creepage and clearance dimensions are rigidly controlled by the mounting of the Ex Components.

NOTE A typical example is a terminal box

6.2 Rotating electrical machines

6.2.1 Determination of starting current ratio I_A/I_N and the time t_E

Where machines with cage rotors are to be subjected to tests with their rotors locked in order to determine the starting current ratio I_A/I_N and the time t_E , the methods of test or of calculation shall be in accordance with Annex A.

Alternatively, where it is not practical to make tests on a machine, calculated figures for the temperature rise in rated service and stalled conditions along with time t_E may be determined. It is preferred that the calculation method be used only to supplement the test method. See the bibliography for references concerning the calculation of locked-rotor temperature.

6.2.2 Mounting of machine for test

Provided that the test conditions are equivalent to the service conditions, rotating electrical machines may be tested with the axis only in the horizontal position, even if they are intended for use with it in other positions.

6.2.3 Additional tests for machines

6.2.3.1 Stator winding insulation system

6.2.3.1.1 Test samples

The tests shall be carried out on one of the following test samples:

- a) one complete stator;
- b) one stator with machine enclosure;
- c) one machine; or

d) a partially wound stator.

In all cases, the test sample shall be in 'as new' condition and shall be representative of a complete stator with, where appropriate, corona shield, stress grading, packing and bracing, impregnation and conductive parts such as the stator core. All exposed conductive parts shall be earthed.

Typical stator connection cables arrangements shall be tested either on one complete stator or in a representative model. Particular care shall be taken with the spacing of the cables, both from each other and from adjacent conductive parts. All such exposed conductive parts shall be earthed. There shall be no interconnections between the phase windings.

6.2.3.1.2 Impulse ignition test for Level of Protection “eb” stator insulation systems

Insulation systems and connecting cables shall be tested in an explosive test mixture as shown in Table 13. They shall be subjected to 10 voltage impulses of not less than three times peak phase to earth voltage and with a voltage rise time between 0,2 μ s and 0,5 μ s, and with a time to half value which is at least 20 μ s. The impulse voltage shall be applied between one phase and earth with the other phases earthed, and repeated for each phase.

NOTE 1 This is a non-standard waveform but it is believed that it is necessary to use as short a rise time as can practically be achieved to initiate discharge with a sufficient length to contain enough energy for ignition. This is based on the results of experiments conducted by Physikalisch-Technische Bundesanstalt (PTB), in Germany.

NOTE 2 This test is representative of wye (star) connected machines with the supply midpoint earthed or delta connected machines with the virtual midpoint near system earth. Other supply connections would need to be the subject of discussions between the manufacturer and the user to determine suitable insulation system tests.

No ignition of the explosive test mixture shall occur.

6.2.3.1.3 Steady state ignition test for Levels of Protection “eb” and “ec” stator insulation systems

Insulation systems and connection cables shall be tested in an explosive test mixture as shown in Table 13 with a sinusoidal voltage of at least 1,5 times the rated r.m.s. line voltage for at least 3 min. The maximum rate of voltage rise shall be 0,5 kV/s. The voltage shall be applied between one phase and earth with the other phases earthed, and repeated for each phase.

No ignition of the explosive test mixture shall occur.

Table 13 – Explosion test mixtures

Equipment Group	Test mixture in air V/V
IIC	(21 \pm 5) % hydrogen
IIB	(7,8 \pm 1) % ethylene
IIA	(5,25 \pm 0,5) % propane

6.2.3.2 Cage rotor

6.2.3.2.1 The test shall be carried out using a machine which has a stator and rotor that are representative of a finished machine in terms of the stator core and windings, and the rotor core and cage. This shall include ducts, centring rings, rings under the end rings and balance discs, where appropriate.

6.2.3.2.2 The rotor cage shall be subject to an ageing process comprising a minimum of five locked rotor tests. The maximum temperature of the cage shall cycle between the maximum

design temperature and less than 70 °C. The applied voltage shall be not less than 50 % of the rated voltage.

6.2.3.2.3 After the ageing process of 6.3.3.2.2, the machine shall be filled with, or immersed in, an explosive test mixture as shown in Table 13. Motors shall be subjected to 10 direct-on-line uncoupled starts or 10 locked rotor tests. These tests shall have a duration of at least 1 s.

No ignition of the explosive test mixture shall occur.

6.2.3.2.4 During the tests, the terminal voltage shall not fall below 90 % of the rated voltage. The concentration of the explosive test mixture shall be confirmed after each test.

6.2.4 Overspeed test of cemented magnets

Prior to the overspeed test, the rotor of a permanent magnet machine using cement to secure the magnets shall be subjected to thermal endurance tests, in accordance with IEC 60079-0, based on the service temperature of the rotor.

In all cases, the rotor shall be rotated at 1,2 times the maximum rated speed for at least 2 minutes. The overspeed test shall be considered satisfactory if there is no visual displacement of the rotor magnets and no contact between the rotor and the stator.

Alternatively if testing of the actual equipment is not practical, to confirm the securing of cemented magnets, the thermal endurance and "overspeed" testing with cemented magnets can be conducted on a representative model taking into consideration the forces that would occur in the actual permanent magnet rotor, including overspeed.

For the thermal endurance tests, it is not recommended that the magnets be magnetized.

Externally driving the rotor for the overspeed test is permitted.

NOTE Additional information on conducting overspeed tests can be found in IEC 60034-1.

6.3 Luminaires

6.3.1 Battery operated luminaires

If the luminaire is supplied by cells or batteries, all tests shall commence with a fully charged battery.

6.3.2 Impact and drop tests

6.3.2.1 General

The lamp filament need not remain intact after the impact or drop tests, conducted in accordance with IEC 60079-0, but the outer bulb shall remain intact.

6.3.2.2 Tests for resistance to impact (portable and transportable luminaires and handlights)

For portable and transportable luminaires and handlights, the applicability of the tests for resistance to impact in IEC 60079-0 are modified as shown in Table 14.

Table 14 – Tests for resistance to impact

Portable and transportable luminaires and handlights	Drop height h $^{0}_{+0,01}$ with 1 $^{0}_{+0,01}$ kg mass m
Guard having maximum individual openings up to 2 500 mm ² ,	0,7
Light-transmitting parts protected by a protruding rim with a minimum height of 2 mm without guard and light transmitting part less than or equal to 5 000 mm ²	0,4
Light-transmitting parts without guard and light transmitting part greater than 5 000 mm ²	0,7
Light-transmitting parts with guard having individual openings up to 2 500 mm ² ; (tested without guard)	0,2
NOTE A guard for light-transmitting parts having individual openings up to 2 500 mm ² reduces the risk of impact, but does not prevent impact.	

6.3.3 Mechanical tests for screw lampholders other than E10

6.3.3.1 Testing the force on the bottom contact of the lamp/lampholder

These insertion and withdrawal tests do not have to be carried out with E10 lampholders.

For type E14, E27 and E40 lampholders, a test lamp cap in accordance with the dimensions specified in IEC 60238 shall be fully inserted into the lampholder, applying an insertion torque as prescribed in Table 15. The test lamp cap shall then be partly withdrawn by rotating through at least 15°. The force on the bottom contact of the lamp shall be not less than 15 N for Level of Protection “eb” or 10 N for Level of Protection “ec”. For type E13, E26, and E39 lampholders, the test shall be performed based on the dimensional requirements of IEC 60238, modified for differences between related lamp caps given in IEC 60061-2.

6.3.3.2 Testing the minimum removal torque of the lamp/lampholder

For type E14, E27 and E40 lampholders, a test lamp cap in accordance with the dimensions specified in IEC 60238 shall be fully inserted into the lampholder, applying an insertion torque as prescribed in Table 15. For type E13, E26, and E39 lampholders, the test shall be performed based on the dimensional requirements of IEC 60238, modified for differences between related lamp caps given in IEC 60061-2.

The test lamp cap shall then be partly withdrawn by rotating through at least 15° and the torque then required to remove the cap shall be not less than the minimum removal torque prescribed in Table 15.

Table 15 – Insertion torque and minimum removal torque

Lamp cap size	Insertion torque Nm		Minimum removal torque Nm	
	“eb”	“ec”	“eb”	“ec”
E14 / E13	1,0 ± 0,1	1,0 ± 0,1	0,3	0,3
E27 / E26	1,5 ± 0,1	1,5 ± 0,1	0,5	0,5
E40 / E39	3,0 ± 0,1	2,25 ± 0,1	1,0	0,75
NOTE Where vibration is severe, special mounting is typically provided for the luminaires.				

6.3.4 Abnormal operation of luminaires

6.3.4.1 Abnormal operations of ballasts for discharge lamps

6.3.4.1.1 Level of Protection “eb”, rectification test

The ballast is supplied at rated voltage with the lamp replaced by a test circuit consisting of a diode and a resistor, in parallel. By varying the resistance, the test circuit current is adjusted to a value at least equal to twice the normal lamp current. The supply voltage is then increased to not less than 110 % of rating without changing the test circuit. When temperatures have stabilized, the temperatures shall not have exceeded the temperature class.

With the diode and resistor in circuit, the ballast is then supplied at rated voltage and when temperatures have stabilized, the limiting temperature shall not be exceeded.

NOTE 1 A diode rated 600 V / 100 A is typically used.

NOTE 2 A variable resistor, 0 to 200 ohms, with a rating at least half the lamp wattage is typically used.

NOTE 3 Although such lamps are not permitted to be used in luminaires of Level of Protection “eb” or “ec”, the ballast itself is permitted to be protected by Level of Protection “eb” or “ec”.

6.3.4.1.2 Level of Protection “ec”

The temperatures determined during the tests shall not exceed the limiting temperature.

The temperatures shall not exceed the values given in the thermal test (abnormal operation) of IEC 60598-1 under conditions representing abnormal service conditions (where applicable but not representing a defect in the luminaire or misuse) using a test voltage as specified in IEC 60079-0.

For windings, the maximum winding temperatures permitted by IEC 60598-1 shall be reduced by 20 K.

The temperature of windings containing thermal protective devices may exceed these temperatures by up to 15 K for 15 min, prior to operation of the protective device.

6.3.4.2 Abnormal operation of luminaires with tubular fluorescent lamps

6.3.4.2.1 Level of Protection “eb”

6.3.4.2.1.1 Rectification test

The luminaire is supplied at a voltage of not less than 110 % of its rated voltage and a diode is then introduced in series with the lamp. When temperatures have stabilized, the temperature shall not have exceeded the temperature class.

With the diode in circuit, the luminaire is then supplied at rated voltage and when temperatures have stabilized, the limiting temperature shall not be exceeded.

It may be necessary to introduce the diode into the lamp circuit after the arc is initiated.

6.3.4.2.1.2 Inoperative lamp test

The luminaire is supplied at a voltage of not less than 110 % of its rated voltage and lamps are removed as necessary to cover all possible combinations and, when temperatures have stabilized, the limiting temperature shall not be exceeded.

6.3.4.2.2 Level of Protection “ec”

There are no additional type test requirements beyond those of the relevant industrial standard, IEC 60598-1.

6.3.4.3 Power dissipation of cathodes of lamps supplied by electronic ballasts

6.3.4.3.1 Luminaires in Level of Protection “eb”

The asymmetric pulse test and the asymmetric power dissipation test in accordance with Annex G shall be conducted. The maximum cathode power observed during the test shall not exceed the values given in Table 16.

The tests shall be conducted at the minimum and maximum ambient temperature of the luminaire.

6.3.4.3.2 Luminaires in Level of Protection “ec”

The asymmetric pulse test and the asymmetric power dissipation test shall be conducted in accordance with IEC 61347-2-3.

The maximum cathode power observed during the test shall not exceed the values given in Table 16.

The tests shall be conducted at the minimum and maximum ambient temperature of the luminaire.

NOTE The relevant industrial standard for electronic ballasts is IEC 61347-2-3.

Table 16 – Power dissipation of cathodes of lamps supplied by electronic ballasts

lamp type	Level of protection		ambient temperature for the luminaire °C	temperature class	maximum cathode power W
	“eb”	“ec”			
T8 /T10/T12	Permitted	Permitted	≤ 40	T4	10
T8 /T10/T12	Permitted	Permitted	≤ 60	T4	8
T8 /T10/T12	Permitted	Permitted	≤ 60	T3	10
T5 (8 W)	Permitted	Permitted	≤ 40	T4	4
T5 (8 W)	Permitted	Permitted	≤ 60	T3	4
T5-HE (8 W to 35 W)	Excluded	Permitted	≤ 60	T4	5

6.3.5 Sulphur dioxide test for Level of Protection “eb” for the connection of bi-pin lamp caps to lampholders

The connections shall be tested in accordance with IEC 60068-2-42 for a period of 21 days with the contacts fully assembled.

After the test, the contact resistance shall not have increased by more than 50 % of the initial value.

Representative lamp cap pins shall be made of brass with a minimum 0,8 µm finish, and chemically brightened.

6.3.6 Vibration test for Level of Protection “eb” for luminaires with bi-pin lamps

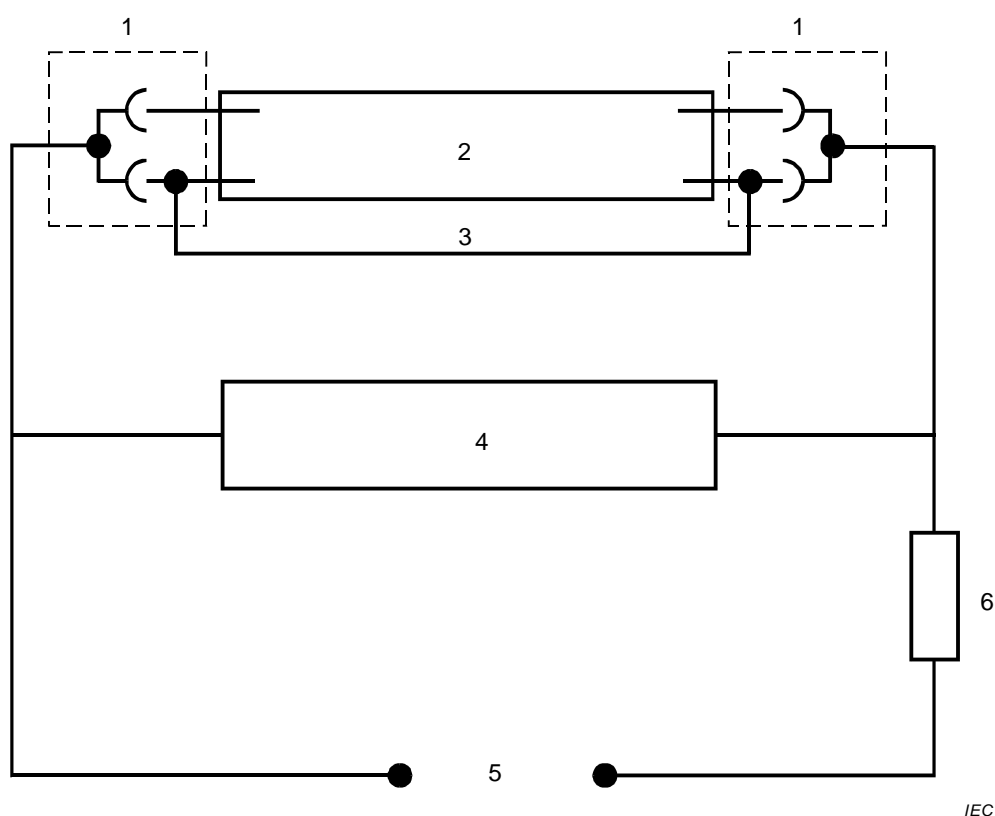
The luminaires shall be submitted to a vibration endurance test in accordance with IEC 60068-2-6.

A complete sample of the luminaire is mounted by its normal fixings to a rigid test fixture, and exposed to frequencies between 1 Hz and 100 Hz.

Between 1 Hz and 9 Hz, the amplitude shall be not less than 1,5 mm; between 9 Hz and 100 Hz, the test unit shall be subjected to an acceleration of not less than 0,5 *g*.

The frequency sweep rate shall be 1 octave per minute with an endurance exposure of 20 cycles in each of the orthogonal planes.

After the exposure, there shall be no visible mechanical damage on all parts of the luminaire. Furthermore, current shall be passed through the lamp contacts, in series using a d.c. supply as shown in Figure 3. If the lampholder contacts are mechanically asymmetrical, the test shall be repeated with the active contacts reversed.



Key

- | | |
|--------------|----------------|
| 1 lampholder | 4 oscilloscope |
| 2 lamp | 5 24 V d.c. |
| 3 connection | 6 resistor |

Figure 3 – Arrangement for the luminaire vibration test

A special test lamp is prepared by disrupting the cathodes using a high current and a lightweight connection made across the lamp.

The current during the test shall be the rated r.m.s. value for the lamp.

During the test, no evidence of current interruption or significant change in contact voltage shall be observed.

6.3.7 Test for wiring of luminaires subject to high-voltage impulses from ignitors

The test voltage at a nominal frequency of 50 Hz or 60 Hz is applied for not less than 1 min between the conductor and a metal foil of width of at least 25 mm wrapped around the external surfaces of the test sample insulation but not nearer than 25 mm to the bare conductors. The test sample is at least 500 mm long.

The voltage is to be not less than 3 kV r.m.s. in circuits using ignitors marked with 2,8 kV, or not less than 5 kV r.m.s. in circuits using ignitors marked 5,0 kV.

No flashover or breakdown shall occur during the test.

6.3.8 Tests for electronic starters for tubular fluorescent lamps and for ignitors in Level of Protection "ec" for discharge lamps

6.3.8.1 General

Ignitors and electronic starters are categorized according to the following features:

- a) the peak pulse voltage (V_{pk}) generated at the lamp does not exceed 1,5 kV, 2,8 kV or 5,0 kV;
- b) the ignitor is or is not fitted with a cut-out device to inhibit repeated starting attempts should the associated lamp either fail to start or fail during operation;
- c) the ignitor does or does not cause the peak pulse voltage to be applied to the ballast winding.

6.3.8.2 Cut-out device test

Where an electronic starter or ignitor is fitted with a cut-out device, three individual units shall be tested at air temperatures of $(-25 \pm 2) ^\circ\text{C}$, $(25 \pm 2) ^\circ\text{C}$ and a temperature that is the maximum service temperature $+(10 \pm 2) \text{ K}$ (unless operating temperature limits are explicitly stated otherwise). Compliance shall be checked as follows:

- a) For starters for tubular fluorescent lamps, the test sample shall consist of the full luminaire circuit with the lamps replaced by resistors to simulate the cathodes. The test sample is energized on ten successive occasions with at least 15 s between starting attempts. The cut-out device shall operate within 10 s to prevent further lamp starting attempts.
- b) For ignitors for discharge lamps, the test sample shall consist of the full luminaire circuit with the lamps removed. The test sample is energized on ten successive occasions with at least 15 s between starting attempts. The cut-out device shall operate within 125 % of the rated time shown on the ignitor.

If all three individual units comply with the requirements, the starter or ignitor shall be classified as "with cut-out device". If any of the three individual units fail to comply, the starter or ignitor shall be classified as "without cut-out device" and subsequent tests shall be carried out on samples with the cutout device isolated or removed so as to render the device inoperative and the ignitor deemed unsuitable for use where the ignitor stresses the ballast winding.

6.3.8.3 Life test (failed lamp)

6.3.8.3.1 Ignitor thermal endurance test

A further three individual ignitors shall pass the following thermal endurance test.

a) Ignitors without a cut-out device

- 1) Place the ignitors in a draught-free oven or enclosure and raise the ambient temperature to not less than 60 °C.
- 2) Energize at the maximum rated operating voltage, at highest operating frequency (or lowest if this produces the highest temperature rise within the ignitor) in a circuit simulating the failed lamp condition.
- 3) Leave the ignitor in a stable state for not less than 60 days.
- 4) De-energize, remove the ignitor from the oven or enclosure and cool to room temperature.

b) Ignitors with a cut-out device

- 1) Place the ignitors in a draught-free oven or enclosure and raise the ambient temperature to not less than 60 °C.
- 2) Energize at the maximum stated operating voltage, at the highest operating frequency (or lowest if this produces highest temperature rise within ignitor), in a circuit simulating the failed lamp condition for a nominal 30 min on 30 min off cycle.
- 3) Continue the test until 500, 30 min on / 30 min off, cycles are complete.
- 4) De-energize, remove the ignitor from the oven or enclosure and cool to room temperature.

6.3.8.3.2 Evaluation criteria

The electronic starter/ignitor shall be examined and shall either:

- a) exhibit no mechanical or electrical defect likely to render the unit inoperative in other than a "safe" condition, or likely to generate an ignition hazard, or
- b) have failed to a "safe" condition without passing through an incandescence mode and without exhibiting any other mechanical or electrical defect.

6.3.9 Test for starter holders for luminaires in Level of Protection "ec"

Three samples of the starter holder are placed in a heating cabinet in which the ambient temperature is maintained at (85 ± 2) °C.

After a total of not less than 72 h, the starter holders are removed from the heating cabinet and allowed to cool for at least 24 h. The contact pressure is then measured by means of a device made according to the dimension of the gauge detailed in IEC 60400.

The contact force shall be not less than 5 N.

6.4 Measuring instruments and instrument transformers

The temperature rise of current transformers with their secondary windings short-circuited and of the current-carrying parts of measuring instruments when the current I_{th} flows for approximately 1 s may be established by calculation or test. In making these calculations, the temperature coefficient of resistance shall be taken into account but heat losses shall be ignored.

The dynamic strength of current-carrying parts shall be verified by testing. Current transformers shall be subjected to the test with their secondary windings short-circuited. The duration of the dynamic test shall be at least 0,01 s with a primary current peak value not less than I_{dyn} for at least one peak.

The duration of the thermal test shall be at least 1 s with an r.m.s. value of primary current not less than I_{th} .

The dynamic test may be combined with the thermal test provided that:

- a) the first major peak current of the test is not less than the dynamic current (I_{dyn}); and
- b) the test is made at a current I for a time t so that (I^2t) is not numerically less than $(I_{th})^2$ and provided t has a value between 0,5 s and 5 s.

An inter-turn overvoltage test shall be carried out on current transformers by the method given in IEC 60044-6 but with an r.m.s. value of primary current equal to 1,2 times the rated value of primary current.

6.5 Transformers other than instrument transformers

The temperature rise of transformers shall be determined by test while connected to the specified load. Any integral or fully-specified protective device shall be in circuit.

Additionally, if the specified load does not form part of the equipment for which compliance with this standard is claimed, the transformer shall be tested under the most adverse load conditions, including short-circuit of secondary windings. Any integral or fully-specified protective device shall be in circuit.

6.6 Verification and tests for cells and batteries of Level of Protection “eb”

6.6.1 General

These type tests are applied to secondary batteries with rated capacity >25 Ah

6.6.2 Insulation resistance

Test conditions are as follows:

- a) the measuring voltage of the ohmmeter shall be at least 100 V;
- b) all connections between the battery and the external circuits and, where fitted, the battery container shall be disconnected;
- c) the cells shall be filled with electrolyte up to the maximum permissible level.

The insulation resistance is considered satisfactory if the measured value is equal to at least 1 MΩ.

6.6.3 Mechanical shock test

6.6.3.1 General

Batteries which are subject to mechanical shocks in normal service shall be submitted to this test. Other batteries are not to be submitted to this test but the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall detail this restriction.

The test shall be carried out only on samples of cells and their connections. Where cells of similar construction are foreseen in a range of capacities, it is not necessary to test every capacity but only a sufficient number of them to allow assessment of the behaviour of the complete range.

6.6.3.2 Test conditions

A test shall be carried out on each sample, comprising at least 2 × 2 new and fully-charged cells complete with intercell connectors, installed in a suitable container. Each sample shall be in ready-for-use condition.

Each sample shall be mounted in its normal operating attitude and by its normal means of attachment, either directly or by means of a rigid fixture, to the mounting surface of the shock machine. The mounting shall satisfy the requirements of 4.3 of IEC 60068-2-27:2008.

The shock machine shall generate a half-sine pulse as shown in Figure 2 of IEC 60068-2-27:2008. The velocity change tolerance, transverse motion and measuring system shall satisfy the requirements of 4.1.2, 4.1.3 and 4.2 respectively of IEC 60068-2-27:2008. The peak acceleration value shall be $5 g_n$, as defined in Table 1 of IEC 60068-2-27:2008.

6.6.3.3 Test procedure

The test procedure for each sample shall be as follows:

- a) the capacity of each sample is determined;
- b) a constant discharge current at the 5 h rate flows during the test;
- c) 15 independent shocks are applied to each sample as follows:
 - three successive shocks in the vertically upwards direction,
 - three successive shocks in each direction along two perpendicular axes in the horizontal plane. These axes are chosen so as to reveal possible weaknesses;
- d) after recharging, the capacity is again determined.

6.6.3.4 Acceptance criteria

The following three conditions shall be satisfied for each sample:

- a) no abrupt change in voltage during the test,
- b) no visible damage or deformation,
- c) no reduction in capacity of more than 5 %.

6.6.4 Test for ventilation of Level of Protection “eb” battery container

The purpose of the test is the determination of the maximum hydrogen concentration within the battery container and the adequate dimensioning of its ventilation openings. For this, hydrogen is released within the battery container.

The flow rate of hydrogen to be released in the battery container shall be determined by the following formula:

$$\text{Hydrogen (m}^3\text{/h)} = \text{number of cells} \times \text{capacity (Ah)} \times 5 \times 10^{-6} \quad (4)$$

NOTE The formula is valid when pure hydrogen is used. When impure hydrogen is used, the flow rate is typically increased to compensate for the impurity of the hydrogen.

One of the following methods may be used. The test shall be carried out at atmospheric pressure in an area free from appreciable draughts.

a) Method 1

That part of the battery container which normally contains the cells shall be fitted with closed boxes. The lids of the boxes shall be provided with filler and vent plugs identical in form, number and location with those on the cells. The location of the boxes shall be such that the natural ventilation normally existing between the cells is unchanged.

Into the space above the boxes, hydrogen shall be fed through the filler and vent plugs with a constant flow corresponding to the type of construction of the cells and to their capacity. The volume of hydrogen required shall be determined from the formula given.

The hydrogen shall be distributed equally amongst all the filler and vent plugs.

b) Method 2

The battery container shall be equipped with a battery made up of cells of the number, type and capacity intended to be used in service.

The cells shall be new, fully charged and connected in series.

An overcharging current shall be passed through the battery to produce hydrogen at a constant flow corresponding to the number, size, type of construction and capacity of the cells in the battery.

The volume of hydrogen to be released shall be determined by the formula given. The overcharging current is determined by the following formula:

$$\text{overcharging current} = \frac{\text{hydrogen}}{\text{number of cells} \times 0,44 \times 10^{-3}} \quad (5)$$

where overcharging current is in amperes and hydrogen is in cubic meters per hour.

At the beginning of the test, the ambient temperature, the temperature of the battery container and the temperature of the cells or of the boxes simulating the cells shall not differ from each other by more than 4 K. These temperatures shall be between 15 °C and 25 °C.

The test shall be continued until four consecutive measurements have shown that the increase in the hydrogen concentration does not exceed the mean of the four measurements by more than 5 %. If the hydrogen concentration decreases in the course of measurement, the maximum measured value shall be considered.

The time interval between consecutive measurements shall be not less than 30 min. If, in the case of continuous measurement, high concentration values are measured for short periods, these may be omitted if the period is less than 30 min.

The measurement of the hydrogen concentration shall be made at different positions beneath the cover in order to locate and measure the highest concentration in the container.

The measurement shall be made approximately central to the upper surface of the cells (or closed boxes) and the cover of the battery container and at a distance from the filler and vent plugs.

The test shall be carried out at least twice.

The test is satisfactory if the hydrogen concentration thus determined does not exceed 2 %.

6.7 Verification and tests for cells and batteries of Level of Protection “ec”

6.7.1 General

NOTE These type tests apply to vented secondary batteries.

6.7.2 Insulation resistance

The requirements of 6.6.2 apply.

6.7.3 Mechanical shock test

The requirements of 6.6.3 apply.

6.7.4 Test for ventilation of Level of Protection “ec” battery container

To verify compliance with 5.6.4.2.2, a H₂ concentration of greater than 90 % V/V shall be reduced to 2 % V/V in not more than 48 h by natural dissipation in still air at a constant temperature.

6.8 General purpose connection and junction boxes

6.8.1 General

The general purpose connection or junction box shall be fitted with a number of the 'worst case' terminals that are wired using conductors of the maximum size specified for that particular terminal. The length of conductor connected to each terminal and contained within the enclosure shall be equal to the maximum internal dimension (three-dimensional diagonal) of the enclosure. The wiring shall be arranged so that the test current is passed through each terminal and its wiring in series. In order to represent the thermal effects of bunching of conductors and also other effects of typical installations, the conductors shall be arranged in groups of six, each with a length outside the box of at least 0,5 m.

A current equal to the rated current of the terminal for the application shall be passed through the series circuit. The temperature of the hottest part shall be measured when steady state conditions have been reached. To facilitate the substitution of alternative terminal types in accordance with Annex E, the temperature rise above local ambient (i.e. immediately surrounding the terminal inside the junction box) shall be determined for the worst case terminal.

NOTE The 'worst case' terminal is that which has been found to exhibit the highest temperature rise. Varying the conductor size, conductor entry location, terminal location / geometry, and terminal size has been found to affect the results.

6.8.2 Maximum dissipated power method

If the limiting value of the maximum dissipated power has to be determined for a particular temperature class, then it is necessary to vary the number of terminals and repeat the test until the limiting temperature is approached. The rated maximum dissipated power (see item a) of 5.7 and Annex E) shall be calculated using the circuit resistance at 20 °C and the rated current applied in the test.

NOTE The rated maximum dissipated power is calculated using the 20 °C resistance value to facilitate the calculation of permissible combinations of terminals, wiring and currents (see Annex E).

6.8.3 Defined arrangement method

As an alternative to specifying only the rated maximum dissipated power, it is possible to specify a set of values relating the junction box dimensions to the specific junction box attributes. Additional information is given in Annex E.

6.9 Resistance heating equipment

6.9.1 The tests shall be carried out on a sample or prototype of the resistance heating device.

6.9.2 The verification of the electrical insulation of the sample or prototype shall be by immersion of the relevant part in tap water at a temperature between 10 °C and 25 °C for not less than 30 min and then subjecting the sample or prototype to the test in a) followed by that in b):

- a) Apply a voltage of $(500 + 2U_n)$ V r.m.s. $^{+5}_{0}$ %, where U_n is the rated voltage of the equipment, for not less than 1 min, with the conductive covering foreseen in 5.8.7 entirely exposed to the water. The voltage is applied between the heating conductor and the conductive covering or, where there is no conductive covering, the water.

When there are two or more conductors electrically insulated from each other, the voltage is applied between each pair of conductors and then between each conductor and the conductive covering or the water. Connections between conductors, including those under insulation, shall be broken if necessary, for example with parallel heating cable.

- b) Measure the insulation resistance with a d.c. source voltage (nominal) of 500 V. The voltage is applied between the heating conductor and the metallic covering, or where there is no metallic covering, the water. The sample or prototype shall have an insulation resistance of at least 20 MΩ.

6.9.3 The thermal stability of the insulating materials of the resistance heating device shall be verified on a sample or prototype by conditioning it in air at a temperature at least 20 K greater than the maximum operating temperature, but not less than 80 °C, for at least 672 hours and subsequently at a temperature between –25 °C and –30 °C for at least 24 h. Compliance of the sample or prototype shall be verified by submitting it to the insulation integrity test of items a) and b) of 6.9.2.

6.9.4 The test for resistance to impact shall be carried out on two new samples or prototypes with equipment similar to that specified by IEC 60079-0. A hemispherical hardened steel impact head shall be used with an impact energy according to the degree of mechanical risk as prescribed in that standard, unless the resistance heating device or unit is protected by an enclosure complying with the requirements for enclosures in IEC 60079-0.

6.9.5 The test for the cold start current shall be carried out on three samples or prototypes of the resistance heating device attached either to a thermal mass or to a heat sink in a cold chamber stabilized at the manufacturer's declared cold start temperature ± 2 K.

The operating voltage shall be applied to the samples without removing them from the cold environment and a continuous record is made of the current flow obtained during the first minute of energization.

6.9.6 Tests for specific forms of resistance heating devices or units shall be carried out in accordance with Annex B.

6.10 Terminal insulating material tests

A sample terminal shall be mounted as intended in service and shall then be subjected to the thermal endurance tests of IEC 60079-0. A copper conductor of the maximum rated size (based on the rated cross section of the terminal) shall then be installed in each connection in accordance with manufacturer's instructions. A pulling force corresponding to the conductor size given in Table 17 shall be applied gradually to each conductor in sequence and maintained at that value for at least 1 min. The conductor shall not become dislodged from the clamping unit, the terminal assembly shall not separate from the terminal insulator, and the terminal insulator shall not crack.

NOTE Dislodging of the terminal from a mounting rail is not considered a failure. Additional terminals or securing devices are typically added to the mounting rail to support the terminal and allow the test to be conducted.

Table 17 – Value for pull-out tests

Size of conductor ISO mm ²	Size of conductor AWG	Pull-out force N
0,5	20	20
0,75	18	30
1,0	17	35
1,5	16	40
2,5	14	50
4	12	60
6	10	80
10	8	90
16	6	100
25	4	135
35	2	190
50	0	236
70	00	285
95	000	351
120	250 kcmil	427
150	300 kcmil	427
185	350 kcmil	503
240	500 kcmil	578
300	600 kcmil	578
350	700 kcmil	645
380	750 kcmil	690
400	800 kcmil	690
450	900 kcmil	703
500	1 000 kcmil	779
630	1 250 kcmil	966
750	1 500 kcmil	1 175
890	1 750 kcmil	1 348
1 000	2 000 kcmil	1 522
NOTE 1 Values derived from IEC 60999-1, IEC 60999-2 and IEC 60947-1.		
NOTE 2 Annex F gives the comparison between AWG and metric sizes.		

7 Routine verifications and routine tests

7.1 Dielectric tests

A dielectric strength test shall be carried out in accordance with 6.1. Alternatively, a test shall be carried out at 1,2 times the test voltage, but maintained for at least 100 ms.

For Level of Protection “ec”, where there is a routine dielectric strength test in the relevant industrial standard for the individual items of electrical equipment, this test is acceptable.

NOTE 1: In some cases, the actual test period might be significantly longer than 100 ms, as a sample with a large distributed capacitance can take longer to reach the actual test voltage.

When the creepage and clearance dimensions are rigidly controlled by tooling in the manufacturing process, the routine tests may be performed on a statistical basis in accordance with ISO 2859-1 with an acceptance quality limit (AQL) of 0,04.

Routine dielectric tests are not required when:

- the equipment contains only Ex Components, with connections complying with IEC 60079-7;
- there is no factory installed interconnecting wiring; and
- all creepage and clearance dimensions are rigidly controlled by the mounting of the Ex Components

NOTE 2: A typical example is a terminal box

7.2 Dielectric tests for batteries

Contrary to 7.1, the dielectric strength test for batteries shall be carried out in accordance with 6.6.2.

The insulation resistance of a battery is considered satisfactory if the resistance is at least 1 MΩ.

7.3 Inter-turn overvoltage tests

An inter-turn overvoltage test shall be carried out on current transformers by the method given in IEC 60044-6, with an r.m.s. value of primary current equal to the rated value of primary current.

8 Ex Component certificates

8.1 General

As the application of increased safety 'e' Ex Components can often affect temperature rise and creepage/clearance, Ex Component certificates shall include the necessary technical information to allow the appropriate evaluation of the application of the Ex Component in equipment.

8.2 Terminals

The schedule of limitations on an Ex Component certificate for terminals shall include the following, where applicable:

- a) details on how the use of qualified terminal jumper accessories can affect the current rating;
- b) details on how the use of qualified terminal accessories can affect creepage and clearance;
- c) details on how different mounting options of terminals can affect creepage and clearance;
- d) details on specific mounting that may be required to provide the required torque resistance;
- e) type and number of conductors per clamping unit;
- f) the limiting temperature of the insulation;
- g) temperature rise when carrying 110 % rated current with specified conductor size(s), See 4.2.2.2;
- h) resistance across the terminal with rated conductor cross-section (as determined by the manufacturer).

9 Marking and instructions

9.1 General marking

These requirements supplement and modify the marking and instruction requirements of IEC 60079-0 which are applicable also to Type of Protection increased safety "e". The Level of Protection "eb" or "ec", shall be shown as the Level of Protection.

Electrical equipment shall be additionally marked with the following:

- a) rated voltage, along with rated current or rated power. If multiple voltage, current or power ratings apply, and all of these ratings are not marked, then only the maximum ratings are required to be marked with the complete rating details shown on the certificate;

For equipment or Ex Components effectively operating at other than unity power factor, both current and power ratings are marked.

- b) for rotating electrical machines in Level of Protection "eb", the starting current ratio I_A/I_N and time t_E ;
- c) for measuring instruments with current-carrying parts and for current transformers, the value of short-circuit current I_{SC} ;
- d) for luminaires, the technical data of the lamps to be used, for example, electrical rating and, if necessary, the dimensions;
- e) for general purpose connection or junction boxes, the rating expressed as either:
 - the rated maximum dissipated power, or
 - the set of values comprising for each terminal size, the permissible number and size of conductor and the maximum current;
- f) restrictions in use, for example use in clean environments only;
- g) the characteristics of special protective devices where required, for example for temperature control or for arduous starting conditions, and special supply conditions, for example for operation only with a converter;
- h) for batteries in accordance with 5.6:
 - type of construction of cells,
 - number of cells and nominal voltage,
 - rated capacity with the corresponding duration of discharge.

If the charger is not protected by a suitable type of protection, the equipment shall carry the marking per item f) of Table 19;

If the battery charger is not protected by a suitable type of protection and requires a period of time to cool below the marked temperature class, the equipment shall carry the marking per item g) of Table 19;

- i) for Ex Component terminals:
 - the conductor range,
 - the rated voltage;

Where marking space is insufficient, this information may appear in the instructions.

As the Type of Protection "e" ratings can be different from the industrial ratings, such ratings should be segregated to the extent possible.

- j) for resistance heating devices and resistance heating units to which the additional requirements of 5.8 apply, the operating temperature.

9.2 Ex Component enclosures

The enclosure shall be marked in accordance with the requirements for marking of Ex Components given in IEC 60079-0, but the marking shall be internal and need not be permanent. The Ex marking string shall not be marked externally.

NOTE A typical Ex marking string for an Ex Component enclosure is Ex eb IIC Gb.

Only manufacturer's name and enclosure identifier information (such as type or serial number) may be marked external to the enclosure. This marking need not be permanent.

These markings may be omitted if the Ex Component enclosure manufacturer is also intended to be the holder of the equipment certificate, and indicated as such in the Ex Component certificate Schedule of Limitations.

9.3 Instructions for use

9.3.1 Battery operated equipment

Instructions for use (instructions for maintenance), for display in the battery charging station, shall be supplied with each battery. These shall include all instructions necessary for charging, use and maintenance.

The instructions for use shall include at least the following information:

- a) the name of the manufacturer or supplier or his registered trade mark;
- b) the manufacturer's type identification;
- c) the number of cells and the nominal voltage of the battery;
- d) the rated capacity with the corresponding duration of discharge;
- e) the charging instructions; and
- f) any other conditions concerning the safe operation of the battery, for example restrictions on the lifting of the cover during charging, the minimum time before closing the cover because of the release of gas after termination of charging, the checking of the electrolyte level, the specifications for the electrolyte and water for topping up, the mounting position.

9.3.2 Terminals

The instructions for use shall include at least the following information:

- a) assigned torque values, if the manufacturer assigns a value of tightening torque;
- b) unless suitable markings are provided, the instructions shall indicate clearly any rearrangement or adjustment that is necessary to adapt to various sizes of conductors, if the rearrangement or adjustment is not obvious;
- c) instructions for proper installation of the conductor for terminal constructions where the wiring method is not obvious;
- d) conductor insulation stripping requirements.

9.3.3 Luminaires

The instructions for use shall include at least the following information.

- a) For bi-pin luminaires, only lamps with brass pins shall be used when installing or replacing lamps.

NOTE Commercially available lamps normally use brass pins.

- b) For luminaires using screw-cap lamps, only lamps with insulating material of the lamp cap complying with the requirements for material group I per IEC 60664-1 and with the

minimum creepage and clearances shown in Table 18 shall be used when installing or replacing lamps.

Table 18 – Creepage distances and clearances for screw lamp caps

Voltage, U V	Creepage distance and clearance mm
$U \leq 10$	1
$10 < U \leq 63$	2
$63 < U \leq 250$	3
<p>When determining the required values for creepage and clearance, the voltage value in the table may be increased by a factor of 1,1 in order to recognize the range of rated voltages in common use.</p> <p>The creepage distance and clearance values shown are based on a maximum supply voltage tolerance of $\pm 10\%$.</p> <p>At 10 V and below, the value of CTI is not relevant and materials not meeting the requirement for material group I may be acceptable.</p>	

9.3.4 Machines

Instructions for use (instructions for maintenance) shall be supplied with each machine. The instructions for use shall include at least the following information:

- details for the routine maintenance and lubrication of bearings;
- where applicable, details for the routine testing of insulated rotor bar insulation.
- For permanent magnet motors, the voltage that may be present at the motor terminals, when the supply is disconnected, when the motor is rotating. Open circuit vs. speed data is normally supplied.
- information on any maintenance required to ensure continued compliance with the rubbing seal requirements of 5.2.12.

9.4 Warning markings

Where any of the following warning markings are required on the equipment, the text as described in Table 19, following the word 'WARNING', may be replaced by technically equivalent text. Multiple warnings may be combined into one equivalent warning.

Table 19 – Text of warning markings

Item	Reference	WARNING Marking
a)	4.2.3.4 4.2.4	WARNING – DO NOT CONNECT OR DISCONNECT WHEN ENERGIZED
b)	4.10.3 a)	WARNING – DO NOT OPEN WHEN NON-INTRINSICALLY SAFE CIRCUITS ARE ENERGIZED
c)	4.10.3 b)	WARNING – DO NOT OPEN WHEN ENERGIZED
d)	4.10.3 b)	WARNING – NON-INTRINSICALLY SAFE CIRCUITS PROTECTED BY INTERNAL IP30 COVER
e)	5.6.2.11	WARNING – DO NOT TRANSPORT THROUGH A HAZARDOUS AREA
f)	9.1	WARNING – DO NOT CHARGE IN A HAZARDOUS AREA
g)	9.1	WARNING – DO NOT TRANSPORT INTO A HAZARDOUS AREA FOR 'Y' MINUTES AFTER DISCONNECTION OF CHARGER
h)	5.9.4	WARNING – DO NOT REMOVE OR REPLACE FUSE WHEN ENERGIZED
i)	5.3.5.2.2	WARNING – RELAMP ONLY IN A NON-HAZARDOUS AREA
j)	4.2.4	WARNING – CONNECT OR DISCONNECT ONLY IN A NON-HAZARDOUS AREA

10 Documentation

Documentation in accordance with IEC 60079-0 shall be prepared, including any additional items specified in this standard.

Essential elements of the documentation for electrical machines include the following:

- a) the degree of protection (IP Code) See 4.10;
- b) the basis of compliance of rotating machines to IEC 60034, including the duty (see 5.2);
- c) for motors in Level of Protection “ec” with duty of S3, S4, S5, S7, S8, or S10 and motor in Level of Protection “eb”; information where special measures are to be employed to ensure that the enclosure of a large rotating motor rated over 100 kW does not contain an explosive gas atmosphere at the time of starting (see 5.2.7.3);
- d) radial air gap (see 5.2.6).

Annex A

(normative)

Temperature determination of electrical machines – Methods of test and of calculation

A.1 General

The maximum permissible surface temperature of the stator winding, rotor parts and ancillary electrical equipment or Ex Components in or on the machine shall be below the limiting temperature. These temperatures shall be measured, determined by extrapolation techniques, or calculated.

- For Level of Protection “eb” electrical machines, expected malfunctions shall be taken into account.

NOTE Expected malfunctions include standstill due to a mechanical overload or locked-rotor situation.

- For Level of Protection “ec” electrical machines with duty types S1, S2, S6, or S9, only temperatures at rated load shall be determined. For Level of Protection “ec” electrical machines with other than duty types S1, S2, S6, or S9, the temperatures shall be determined during frequent starting or varying load conditions, as applicable, depending upon the specific duty type.
- For Level of Protection “eb” or “ec” electrical machines, intended to be operated with a converter, temperatures shall be determined as specified in 5.2.8.4.

The determination of temperature employing the calculation or extrapolation methods shall be based on comparative temperature measurements on similar machines.

A.2 Determination of maximum service temperatures

A.2.1 Rotor temperature – normal operation

The temperature of the rotor, with the machine operated under rated conditions, shall be determined directly after switching off the machine as specified in IEC 60034-1. A plot back to time zero shall be used to determine the maximum rotor temperature. Alternative methods such as peak recording, temperature sensitive, paints or dots may be used to determine the maximum temperature.

Although, for cage rotors, the temperature of the end rings and the rotor bars may be different with the center of the rotor core greater than the ring temperature, the difference between the various bars and the ring is negligible when running at normal load condition, and only the end ring temperature need be determined. A large machine may have access to the rings or at the bar extension for temperature measurements.

A.2.2 Winding temperature – normal operation

The winding temperature shall be determined by the resistance method directly after switch off of the machine. As the machine cools down quickly after switch off (the machine continues to rotate and does not immediately stop), a plot back to time zero of winding resistance is required using an exponential curve fit technique to determine the maximum temperature at the time of shut down. For winding temperatures measured by embedded temperature sensors, the stator winding temperature determination shall be made using the highest temperature indicated by any embedded temperature sensor.

NOTE This requirement is in addition to those of IEC 60034-1. Although this provides the average temperature of the winding conductors, it is considered to represent the maximum surface temperature on the surface of the insulated winding.

A.3 Determination of maximum surface temperatures

A.3.1 General

IEC 60079-0 specifies that the maximum surface temperature is to be determined with an input voltage of 90 % to 110 % of the rated voltage that gives the maximum surface temperature. Alternatively, in the case of electrical machines, the voltage may be based on operation within "Zone A" according to IEC 60034-1 with typically ± 5 % of rated voltage (with a corresponding marking of the specific conditions of use). The maximum surface temperature of the stator and rotor windings shall be determined in accordance with IEC 60034-1, with the above adjustment for voltage taken into consideration. Loading of large rotating machines shall be according to IEC 60034-29.

NOTE The suitability of insulating materials and of non-metallic parts of enclosures on which the type of protection depends is based on maximum service temperature which is determined at rated voltage, without a voltage adjustment.

A.3.2 Locked rotor tests

A.3.2.1 Test conditions

The motor shall be initially at rest, with the rotor and stator stabilized to that of the surrounding laboratory ambient temperature. With the rotor locked, rated voltage and rated frequency shall be applied. If the locked rotor test is carried out at reduced voltage due to limitations of the test laboratory, the temperature values shall be determined according to A.3.2.2.

A.3.2.2 Optional testing at reduced voltage

The measured value of current shall be increased in proportion to the ratio of test voltage to rated voltage, and the measured value of temperature shall be increased in proportion to the square of the ratio of those voltages. Saturation effects, if any, shall be taken into account, based on an estimation of the saturation effects by the manufacturer. The test shall be performed at the highest available voltage at or below the rated voltage, not lower than 50 % of the rated voltage.

A.3.2.3 Rotor temperature

The temperature of the rotor, with the machine operated under locked rotor conditions, shall be determined for Level of Protection "eb" machines to determine time t_E or confirm protection by embedded temperature sensors as follows. The temperature rises in the rotor cage (bars and rings) shall be measured by temperature sensors having a time constant that is small compared with the rate of rise of temperature. Due to the skin effect, the highest temperature rises occur at the upper edge of the bars. Therefore if thermocouples are used, they shall be inserted as close as possible to the surface of the bars. The highest of the temperatures determined is the one to be used as the basis of the temperature class.

For motors of conventional design with die cast rotors, with a power of less than 500 kW, if thermocouples are placed in just two rotor bars 90 electrical degrees apart then an increase of 10 % on the higher measured temperature rise value will allow for any other rotor bar with a high temperature. For other machines, a minimum of 3 rotor bars, distributed over 90 electrical degrees, should be instrumented, with at least three thermocouples per bar. On each bar, thermocouples should be located in the centre, near the end, and at the endring.

NOTE The temperature rise of individual rotor bars will vary according to their position relative to the space harmonics of the stator winding phase bands. This variation will be at least 20 % for motors with low spatial harmonics but can be significantly greater.

A.3.2.4 Determination of starting current I_A

The stator current measured ($5_{-0,5}^{+0,5}$) s after switching on shall be considered to be the starting current I_A . If the optional reduced voltage testing in accordance with A.3.2.2 is employed, the stator current shall be “corrected” as detailed therein.

A.3.2.5 Stator temperature

The average temperature rise of the stator, as determined from resistance measurements, is taken as the temperature rise of the winding. A plot back to time zero of winding resistance is required using an exponential curve fit technique to determine the maximum temperature at the time of shut down. For machines protected by an embedded temperature sensor, the winding temperature determination shall be made after the embedded temperature sensor and associated protective system has initiated switch off.

A.4 Optional calculation of maximum surface temperature

A.4.1 General

As an alternative to A.3, the temperature rises of the rotor and of the stator winding, with the rotor locked, to determine time t_E may be calculated. The determination by calculation of the rotor currents (used for the calculation of the rotor temperature) shall be based on models previously validated by actual test results. For the stator starting current see A.3.2.4.

A.4.2 Rotor temperature

When calculating the temperature of the rotor, the temperature rise shall be calculated from the joule heating effect, taking account of the heat generated in the bars and rings as well as of the thermal capacity of the cage. The influence of skin effect on the heat distribution in the rotor bars shall be considered. Allowance may be made for the heat transfer to the iron.

A.4.3 Stator temperature

The rate of temperature rise with time, $\Delta\theta/t$, of the stator windings in the motor shall be calculated as follows:

$$\frac{\Delta\theta}{t} = a \times j^2 \times b \quad (\text{A.1})$$

where

j is the starting current density, in A/mm²;

a is the coefficient in $\frac{\text{K}}{(\text{A/mm}^2)^2 \text{ s}}$ (for copper, $a = 0,0065$);

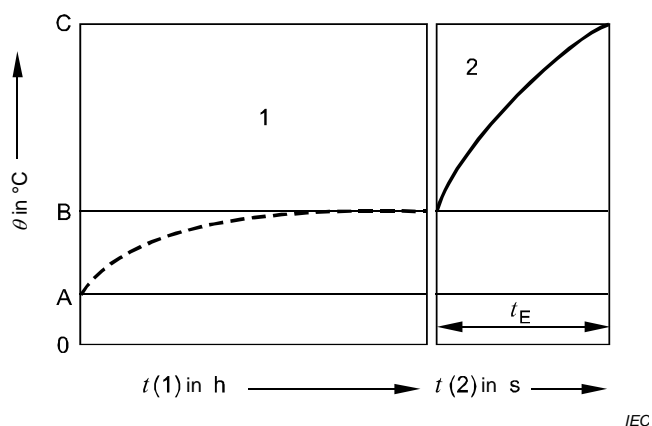
$b = 0,85$ (a reduction factor which takes into account the heat dissipation from impregnated windings).

A.5 Determination of t_E time

The time t_E shall be determined as follows (see Figure A.1).

From the limiting temperature C, the maximum ambient temperature A (normally 40 °C) and the temperature rise in rated service B are subtracted. From this difference BC, and the rate of temperature rise during the locked rotor test (obtained by measurement or calculation), the time t_E is determined.

Separate calculations are made for the rotor and for the stator. The smaller of the two values is taken as the time t_E for the motor, for the appropriate temperature class.



Key

A highest permissible ambient temperature

θ temperature

B temperature in rated service

1 temperature rise in rated service

C limiting temperature (see 5.2.8 and 4.8)

2 temperature rise during locked rotor test

t time

Figure A.1 – Diagram illustrating the determination of time t_E

A.6 Arduous starting conditions

Motors designed for arduous starting conditions or provided with special protective devices (for example, devices monitoring the temperature of the windings) shall be tested in conjunction with those protective devices.

A.7 Motors operated with a converter

Motors intended to be operated with a converter and any associated safety device shall be tested to determine that the relevant limiting temperatures are not exceeded over the range of operating conditions given by the combination of motor and converter.

Annex B

(normative)

Type tests for specific forms of resistance heating devices or resistance heating units (other than trace heater)

B.1 Resistance heating devices subjected to mechanical stresses

Flexible resistance heating devices not mechanically protected by an enclosure complying with the requirements for enclosures of IEC 60079-0, shall conform to the crush and low temperature bending tests described in IEC 60079-30-1.

B.2 Resistance heating devices or units intended for immersion

A sample, or part of the sample intended for immersion, is immersed under at least 50 mm of potable water, for at least 14 days. Compliance is then verified by the insulation integrity test in items a) and b) of 6.9.2.

NOTE This test is not intended to verify the suitability of resistance heating devices or units to operate when immersed in liquids other than water or at pressures of more than 500 Pa.

B.3 Resistance heating devices or units having hygroscopic insulating material

The parts which ensure vapour tightness are subjected to a temperature of $(80 \pm 2) ^\circ\text{C}$ for at least 672 hours at not less than 90 % RH. After being wiped dry, compliance of the sample is verified by the insulation integrity test in items a) and b) of 6.9.2 but omitting the water immersion.

The documentation in accordance with IEC 60079-0 shall specify the process and the materials to be used to complete the sealing of the resistance heating device or unit.

B.4 Verification of limiting temperature of resistance heating devices (other than trace heaters)

B.4.1 General

The test shall be carried out in accordance with the procedure of B.4.2, B.4.3 or B.4.4.

B.4.2 Safety devices

B.4.2.1 General

Resistance heating unit protected by a safety device in accordance with 5.8.11. The test shall be carried out at the power output of the equipment corresponding to 10 % overvoltage with any declared minus tolerance on the ohmic resistance.

Heating units protected by a safety device according to 5.8.11, but tested without the safety device, may be certified as equipment only if the operating conditions are simulated during the test. Otherwise, the heating unit can only be regarded as an Ex Component.

B.4.2.2 Safety device sensing the temperature

The maximum temperature permitted by the safety device shall be determined with any additional regulating devices rendered inoperable. Thermal time constants to ensure stable temperatures shall be taken into account.

B.4.2.3 Safety device sensing the temperature and at least one other parameter

The maximum temperature shall be determined as in B.4.2.2 taking into account the most adverse conditions permitted by the device(s) sensing the other parameter(s).

B.4.2.4 Safety device sensing a parameter other than the temperature

The maximum temperature shall be determined taking into account the most adverse conditions permitted by the devices sensing the other parameter(s).

B.4.3 Resistance heating unit of stabilized design

The sample shall be tested in the worst installation conditions specified by its manufacturer and recognized as such by the testing station. These test conditions shall include, where relevant, zero fluid flow or an empty pipe or vessel. The test is carried out at the power output determined as in B.4.2.

Simulated operating conditions may be utilized.

B.4.4 Heating device with temperature self-limiting characteristic

In the case of a cable or tape, a sample between 3 m and 4 m in length shall be close-coiled inside a close-fitting box of thermally insulating material, capable of withstanding the temperature produced. The box shall be effectively adiabatic. Thermocouples shall be attached to the sample to measure its maximum surface temperature. The sample shall then be energized at $1,1 U_n^{+5}_0$ % at an initial temperature of $(-20 \pm 3) ^\circ\text{C}$ until thermal equilibrium is reached.

The maximum temperature shall be determined.

Other resistance heating devices with a temperature self-limiting characteristic shall be similarly tested in an effectively adiabatic enclosure.

Annex C (informative)

Cage motors – Thermal protection in service

C.1 This annex gives additional information for the user as guidance for the selection of safety devices with particular reference to those installation requirements that are different from, or supplementary to, practice in normal industrial installations.

C.2 To satisfy the requirements of 5.2.8.2 in service, an inverse-time delay overload safety device (for example, a direct-on-line starter with thermal overload relay or release) is acceptable provided that it satisfies the recommendations of Clause C.3.

C.3 Inverse-time delay overload safety devices should be such that not only is the motor current monitored but also that the stalled motor will be disconnected within the time t_E . The current-time characteristic curves giving the delay time of the overload relay or release as a function of the starting current ratio I_A/I_N should be in the possession of the user.

The curve should indicate the value of delay time from the cold state related to an ambient temperature of 20 °C and for a range of starting current ratios of at least 3 to 8. The tripping time of the safety devices should be equal to these values of delay time $\pm 20\%$.

C.4 In general, motors for continuous service, involving easy and infrequent starts which do not produce appreciable additional heating, are acceptable with inverse-time delay overload protection. Motors for arduous starting conditions or to be started frequently are acceptable only when suitable safety devices, which ensure that the limiting temperature is not exceeded, are used.

Arduous starting conditions are considered to exist if an inverse-time delay overload safety device, correctly selected according to Clause C.3, disconnects the motor before it reaches its rated speed. Generally, this will happen if the total starting time exceeds 1,7 times t_E .

For motors in Level of Protection “ec”, sealed devices may be used as safety devices.

Annex D (informative)

Resistance heating devices and units – Additional electrical protection

D.1 Objective

The function of this protection, which is additional to the overcurrent protection, is to limit the heating effect and possible arcing due to abnormal earth fault and earth leakage currents.

D.2 Method of protection

This will depend on the type of system earthing (see IEC 60364-5-55 for definitions).

a) TT and TN systems

A residual current operated protective device with a rated residual operating current not exceeding 100 mA should be used.

Preference should be given to protective devices with a rated residual operating current of 30 mA. This protective device should have a maximum break time not exceeding 100 ms at the rated residual operating current.

NOTE 1 Typically, this system will disconnect all non-grounded phases at a trip level of 30 mA or higher.

NOTE 2 Additional information on residual current protective devices is given in IEC 61008-1.

b) IT system

An insulation monitoring device should be installed to disconnect the supply whenever the insulation resistance is not greater than 50 Ω/V of rated voltage.

Annex E **(informative)**

Combinations of terminals and conductors for general purpose connection and junction boxes

E.1 General

In most types of electrical equipment, the source of heat is a well-defined part of that equipment. However, for general purpose connection and junction boxes containing only an array of terminals, the principal source of heat is more likely to be the cables connected to those terminals than the terminals themselves and therefore the actual installation is a critical factor. This fact needs to be recognized in any system of allocating a rating to such general purpose connection and junction boxes for the purpose of allocating a temperature class.

The maximum temperature rise within the enclosure of such a box depends on two factors:

- the overall population of terminals and wiring within the enclosure, leading to an increased local temperature within the enclosure; and
- the temperature rise of individual terminals and wiring above their own local temperature.

The 'worst case' terminal referred to in 6.8 is chosen to be a terminal, which in conjunction with its maximum rated conductor, exhibits the highest temperature rise above the local temperature. Any terminal can be used with a temperature rise lower than that of the worst case terminal.

NOTE This Annex gives additional information relevant to the two methods of expressing the rating of general purpose connection and junction boxes.

E.2 Maximum dissipated power method

The rated maximum dissipated power is determined in accordance with 6.8 using the 'worst case' terminal. For an allocated temperature class, the enclosure may be fitted with any number of recognized terminals which may or may not include the 'worst case' terminal, up to the maximum number permitted by the physical constraints of the enclosure, provided that the rated maximum dissipated power is not exceeded.

For each terminal, the dissipated power is calculated using the maximum current for that terminal and the value of resistance at 20 °C for the terminal and its associated conductor(s). Each conductor is assumed to have a length from the cable gland to the terminal equal to 0,5 times the maximum internal dimension (three-dimensional diagonal) of the enclosure, that is, the length of the conductor from the cable gland to the terminal is assumed to be one half the length of the terminal to terminal conductor used in 6.8. The sum of these dissipated powers represents the total dissipated power for the configuration and circuit condition. It should not exceed the rated maximum dissipated power.

NOTE To assist in the calculations for an installation, the Ex Component certificate for terminal blocks specifies resistance values at 20 °C for terminals.

E.3 Defined arrangement method

As an alternative to specifying only the rated maximum dissipated power, it is possible to specify a set of values relating the junction box dimensions to the following intended junction box attributes:

- conductor length (based on three-dimensional diagonal of the box),

- If more than one combination of values based on the above attributes is possible, then the information may be given in the form of a table (see Figure E.1). Actual testing, thermal calculations or both are to be used in the development of such tables. Either a separate table shall be created for each box dimension or, if a “series” of box dimensions are grouped under one table, then that one table shall be based on the worst case box dimensions in the “series”. Tables under either approach can be identified by specific box dimensions or by a specific box designator that relates to specific box dimensions.

(Specific Junction Box Designator or Specific Box Dimensions)															
Current	Number of Conductors ^a (based on cross-section in mm ²)														
A	1,5	2,5	4	6											
3	a	a	a	a											
6	a	a	a	a											
10	40	a	a	a											
16	13	26	a	a											
20	5	15	30	a											
25	b	7	17	33											
35	b	b	3	12											
50	b	b	b	b											
63	b	b	b	b											
Maximum number of terminals ^a	20	13	15	16											

All incoming conductors and internal links count as conductors, earth connections do not count.

When using this table, the simultaneous factor or the rated load factor in accordance with IEC 60439 may be taken into consideration. Mixed sizes of conductors with circuits of different cross-sections and currents are possible when the table values are used in the respective proportions.

^a Any number of conductors and terminals additionally.

^b To be engineered by the manufacturer (with heat rise calculation).

Cross-section/mm ²	Current/A	Quantity	=	Utilization
1,5	10	20 (of 40)	=	50 %
2,5	20	5 (of 15)	=	33,3 %
4	25	2 (of 17)	=	<u>11,7 %</u>
		Total < 100 %	=	<u>95,0 %</u>

Figure E.1 – Example of defined terminal/conductor arrangement table

Annex F (normative)

Dimensions of copper conductors

Table F.1 gives the standard cross-sections of copper conductors.

Table F.1 – Standard cross-sections of copper conductors

Metric size ISO mm ²	Comparison between AWG/kcmil and metric sizes	
	Size AWG/kcmil	Equivalent metric area mm ²
0,2	24	0,205
-	22	0,324
0,5	20	0,519
0,75	18	0,82
1	-	-
1,5	16	1,3
2,5	14	2,1
4	12	3,3
6	10	5,3
10	8	8,4
16	6	13,3
25	4	21,2
35	2	33,6
50	0	53,5
70	00	67,4
95	000	85
-	0000	107,2
120	250 kcmil	127
150	300 kcmil	152
185	350 kcmil	177
240	500 kcmil	253
300	600 kcmil	304
350	700 kcmil	355
380	750 kcmil	380
400	800 kcmil	405
450	900 kcmil	456
500	1 000 kcmil	507
630	1 250 kcmil	634
750	1 500 kcmil	760
890	1 750 kcmil	887
1 000	2 000 kcmil	1 014

Annex G

(normative)

Test procedure for T5 (only 8 W), T8, T10 and T12 lamps

G.1 Asymmetric pulse test

G.1.1 General

The ballast shall have adequate protection to prevent lamp cap overheating at the end of the lamp life. When subjected to the following test, the maximum cathode power shall not exceed the values given in Table 16.

G.1.2 Test procedure

Refer to the schematic diagram in Figure G.1.

The ballast shall be connected to J2 and the lamp to J4.

- a) Close switches S1 and S4, and set switch S2 to position A.
- b) Turn on the ballast under test and allow lamp(s) to warm up for 5 min.
- c) Close S3, open S1, and wait for 30 s.
- d) Measure the sum of the average power dissipated in the power resistors, R1A to R1C and R2A, R2B and the Zener diodes, D5 to D8.

This power should be measured as the average value of the product of the voltage between terminals J5 and J6 times the current flowing from J8 to J7. The voltage should be measured with a differential voltage probe, and the current should be measured with a d.c. current probe. A digital oscilloscope can be used for the multiplication and averaging functions. If the ballast operates in a cycling mode, the averaging interval should be set to cover an integer number of cycles (each cycle is typically greater than 1 s). The sampling rate and number of samples included in the calculations should be sufficient to avoid aliasing errors.

If the measured power is greater than the values given in Table 16, the ballast has failed and the test is discontinued.

- e) If the protection circuit in the ballast has switched off the lamp, then the ballast shall be restarted (close S1).
- f) Open S4 and S1 and wait for 30 s.
- g) As in d), measure the sum of the average power dissipated in the power resistors, R1A to R1C, R2A and R2B, and the Zener diodes, D5 to D8.

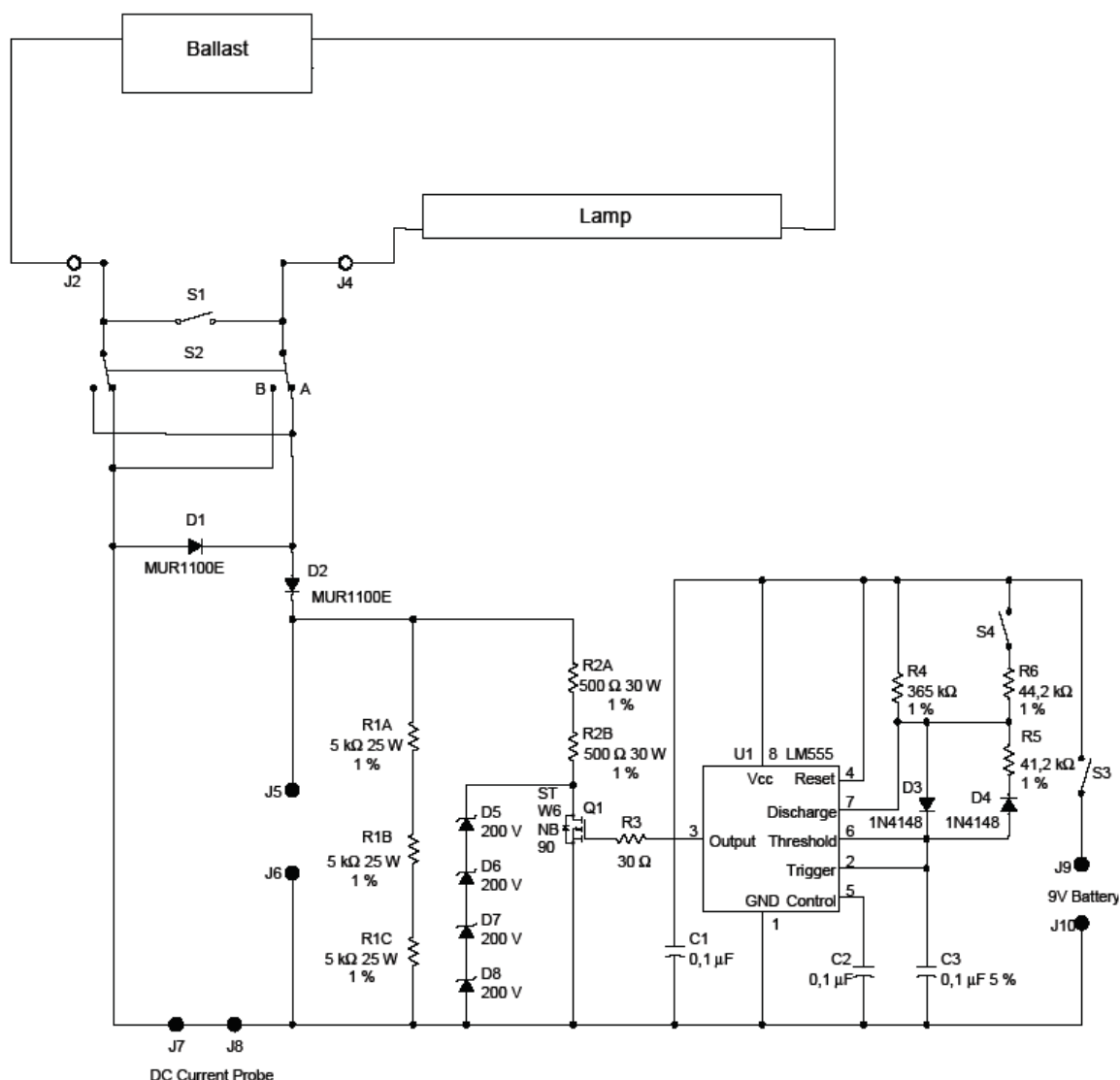
If the measured power is greater than the values given in Table 16, the ballast has failed and the test is discontinued.

- h) If the protection circuit in the ballast has switched off the lamp, then the ballast shall be restarted (close S1).
- i) Close S1 and S4.
- j) Set S2 to position B.
- k) Repeat steps b) to g).

The ballast shall pass both position 'A' and position 'B' tests.

- l) For multi-lamp ballasts, repeat steps a) to k) for each lamp position. A multi-lamp ballast shall pass the tests for each lamp position.

- m) For ballasts that operate multiple lamp types, each lamp type specified shall be tested. Repeat steps a) to l) for each lamp type.



IEC

Figure G.1 – Asymmetric pulse test circuit

FET Q1 should be on for approximately 3 ms and off for approximately 3 ms when S4 is closed, and on for approximately 27 ms and off for approximately 3 ms when S4 is open.

A list of material and transformer specifications is given in IEC 61347-2-3. Any other transformer components with the same functionality are permitted.

G.2 Asymmetric power test

G.2.1 General

The ballast shall have adequate protection to prevent lamp cap overheating at the end of the lamp life. When subjected to the following tests, the maximum cathode power shall not exceed the values given in Table 16 with the lamp at a temperature representative of its maximum service temperature.

G.2.2 Test procedure

Refer to the schematic diagram in Figure G.2 and the flowchart of Figure G.3. It is critical that the inductance of resistor R1 be as low as possible (ohmic resistor) due to the high frequency of this circuit.

- a) Set switch S1 to position A.
- b) Set resistance of resistor R1 to shorted.
- c) Start lamp(s) by turning on power to ballast under test and allow lamp(s) to warm up for 5 min.
- d) Increase the resistance of R1 rapidly (within 15 s), until the power dissipated by resistor R1 equals the test wattage value of 20 W (8 W for the T5 lamp 8 W). (if required, making further adjustments to R1 during the first 15 s).
 - If the ballast switches off before reaching the test wattage, or after reaching the test wattage, the ballast shall be retested to demonstrate that the maximum possible continuous power, without switching off, is less than or equal to the values given in Table 16.
 - Increase the resistance of R1 rapidly (within 15 s) until the power dissipated by resistor R1 equals approximately 5 W (2 W for the T5 lamp 8 W).
 - If the ballast fails to turn off in 2 min, stop the test and repeat with an increased resistance in R1.
 - Continue repeating the test with increasing values of R1, approaching a target power dissipation of the values given in Table 16 (three or four steps is sufficient.).
- e) If the ballast fails to switch off within 2 min at a power less than or equal to the values given in Table 16, the ballast has failed and the test is discontinued. If the ballast does not switch off in the test of d), but limits the power in R1 to a value less than the test wattage of 20 W (8 W for the T5 lamp 8 W), set R1 to the value which produces the maximum wattage.
- f) If the 20 W (8 W for the T5 lamp 8 W) value was reached in step d), wait for an additional 15 s. If the 20 W (8 W for the T5 lamp 8 W) value was not reached in step d) and the limitation obtained at e) is applicable, wait for an additional 30 s. Then measure the power in resistor R1.

If the power in resistor R1 has not reduced to the values given in Table 16 or less, the ballast has failed and the test is discontinued.

If the power in resistor R1 is greater than the values given in Table 16, the ballast has failed and the test is discontinued.
- g) Turn off power to ballast. Set switch S1 to position B.
- h) Repeat test procedure steps b) to e) above. The ballast shall pass both position 'A' and position 'B' tests.
- i) For multi-lamp ballasts, repeat test procedure steps a) to g) for each lamp position. A multi-lamp ballast shall pass the tests for each lamp position.
- j) For ballasts that operate multiple lamp types each lamp type specified shall be tested. Repeat steps a) to h) for each lamp type.

In any of these configurations, if the power in resistor R1 is greater than the values given in Table 16, the ballast has failed and the test is discontinued.

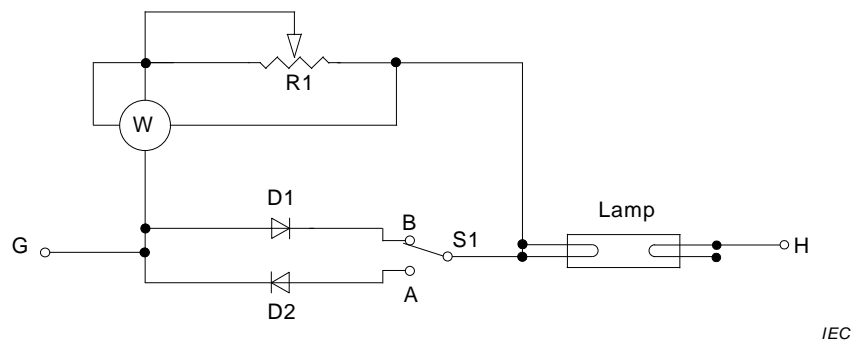
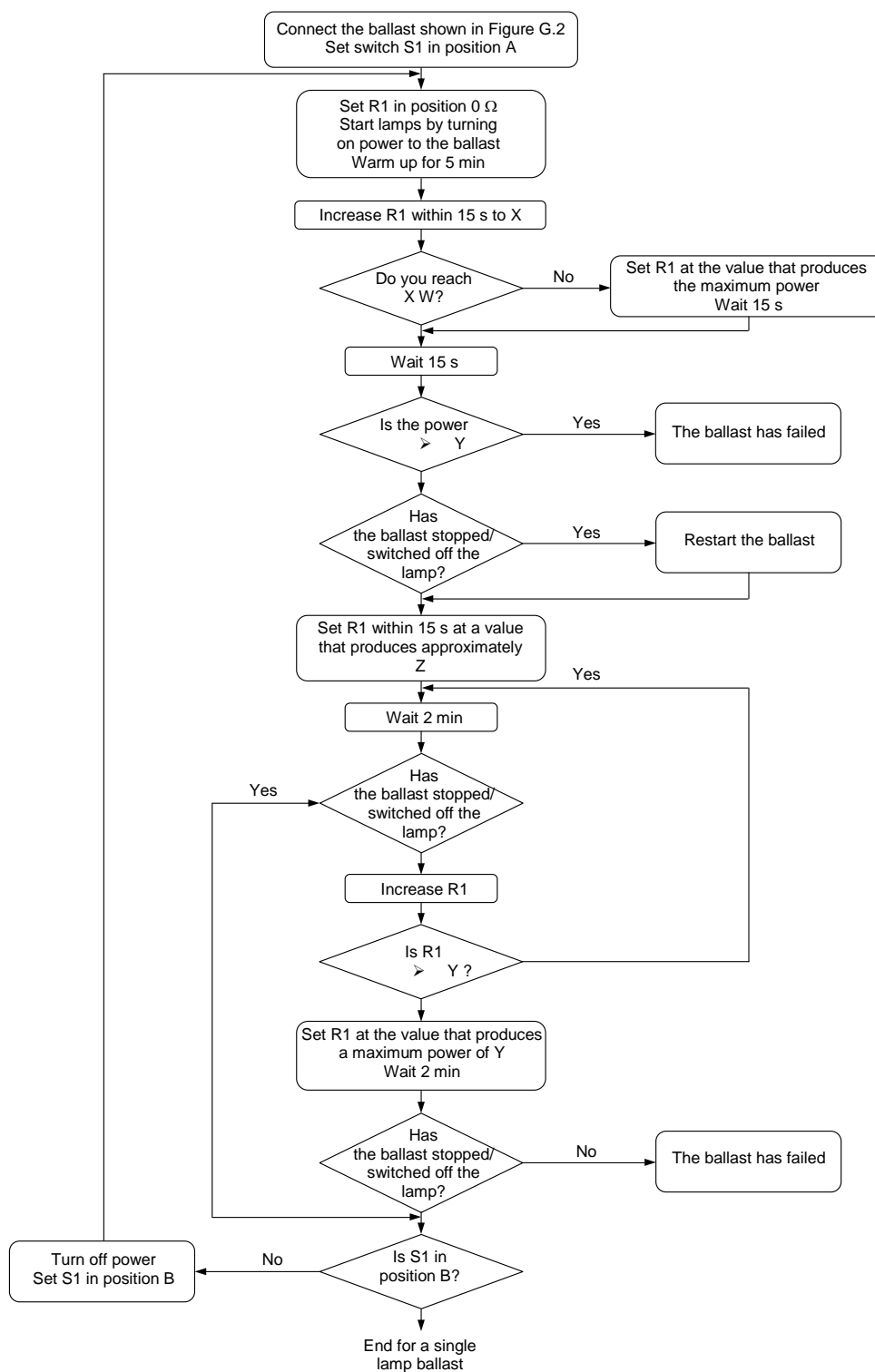


Figure G.2 – Asymmetric power detection circuit



IEC

Figure G.3 – Flow Chart – Asymmetric power Test for T8, T10, T12 and T5 (8 W lamps)

X = twice the value as given in Table 16

Y = Value as given in Table 16

Z = half the value as given in Table 16

Annex H (normative)

Alternative separation distances for Level of Protection “ec” equipment under controlled environments

H.1 General

Conformity with this Annex yields reduced separation distances of conductive parts with respect to Table 2 for electronic and allied equipment, assemblies and sub-assemblies of Level of Protection “ec” used for example, for measurement, control or communication purposes.

This Annex is only applicable when **all** of the following conditions are met:

- The equipment is intended for installation in an area providing at least pollution degree 2 (See H.3);
- The equipment is providing an enclosure with a minimum ingress protection IP54 (See H.2);
- The equipment is providing, or is provided with a voltage limitation (See H.4); and
- The equipment is providing, or is provided with a controlled overvoltage condition involving transient protection for equipment of overvoltage category II affect electrical segregations under control (See H.5).

Conformity with the requirements in this Annex for **all** of these conditions is necessary to reduce separation distances in accordance with the alternative separation distances of this Annex.

The minimum separation distances stated in this Annex are valid for circuits with limited possible overvoltage stress and not directly connected without further means to mains circuits.

The general requirements for separation distances of conductive parts are given in Clause 4 of this standard. In controlled environments as noted above, the requirements of this Annex may offer less onerous construction requirements. The allowance for these alternative separation distances for equipment under these controlled environments is based on IEC 60664-1, *Insulation coordination for equipment within low voltage systems*. To minimize the risk of uncontrolled overvoltages transient protection shall be used.

H.2 Specific Conditions of Use

When the pollution degree, ingress protection or transient protection are to be fulfilled by the installation of the equipment, the certificate number shall include the “X” suffix in accordance with the marking requirements of IEC 60079-0 and the appropriate Specific Conditions of Use listed on the certificate shall be worded as follows, or equivalent.

- “The equipment shall only be used in an area of at least pollution degree 2, as defined in IEC 60664-1.”
- “The equipment shall be installed in an enclosure that provides a minimum ingress protection of IP 54 in accordance with IEC 60079-0”.
- “Transient protection shall be provided that is set at a level not exceeding 140 % of the peak rated voltage value at the supply terminals to the equipment”.

NOTE Regarding the first “X” condition above, a minimum permitted pollution degree is specified, as opposed to simply including a general statement about needing to maintain a “suitable environment”. It is important to note that an IP 54 rated enclosure alone does not provide a pollution degree 2 environment.

H.3 Control of pollution access

The pollution level shall be limited to pollution degree 2 or better as defined in IEC 60664-1, and the enclosure for the equipment shall provide a degree of protection not less than IP54.

Pollution degree 2 can be achieved when the installation is in a controlled environment with suitably controlled condensation or airborne pollution.

In addition, the enclosure for the equipment shall provide a degree of protection not less than IP54 in accordance with the test of enclosure section of IEC 60079-0 unless the equipment is intended to be afforded an equivalent degree of protection by location.

NOTE Additional information on the reduction of pollution degree by control of condensation or airborne pollution can be found in IEC 60664-1.

H.4 Voltage limitation

The voltage shall be limited to a rated voltage up to 275 V a.c. or 390 V d.c.

H.5 Control of overvoltages and transient protection

Provision shall be made, either in the equipment or external to the equipment, to provide the transient protection device to be set at a level not exceeding 140 % of the peak rated voltage value of 85 V or of the peak rated voltage values at the power supply terminals of the equipment given in Table H.1. The transient protection shall limit transients up to a maximum of 140 % of the peak voltage values for the steps given in Table H.1 that the equipment falls into, determined by the maximum input voltage of the equipment in normal operation.

H.6 Alternative separation distances

If the rated voltage of the equipment or the working voltage of any part of the equipment being considered does not exceed 60 V a.c. or 85 V d.c. no minimum creepage and clearance requirements are specified beyond those of the relevant industrial standards based on pollution degree 2 requirements.

Equipment with a rated voltage of over 60 V a.c. or 85 V d.c. up to 275 V a.c. or 390 V d.c. shall conform to the creepage and clearance requirements in Table H.1.

NOTE Where the relevant industrial standards are not based on a specific pollution degree, the creepage and clearance requirements are assumed to have been based on pollution degree 3.

Non-sparking equipment circuits may be included in assemblies and sub-assemblies that comply with 4.3 and 4.4 provided the separations between the non-sparking equipment circuits and all other circuits meet the requirements of 4.3 and 4.4.

Table H.1 – Alternative separation distances for equipment under controlled environments

Peak Voltage Value ^b V	Minimum creepage distance ^a (Note 1) mm			Minimum clearances and separations ^a mm	
	Material group			Clearance	Distance Under coating (Note 2)
	I	II	III		
≤ 90	0,63	0,9	1,25	0,4	0,3
≤ 115	0,67	0,95	1,3	0,4	0,4
≤ 145	0,71	1	1,4	0,4	0,4
≤ 180	0,75	1,05	1,5	0,5	0,4
≤ 230	0,8	1,1	1,6	0,75	0,55
≤ 285	1	1,4	2	1	0,85
≤ 355	1,25	1,8	2,5	1,25	0,85
^a For printed circuit boards mounted in clean dry conditions as defined in IEC 60664-1, the minimum creepage distances can be reduced to the values of the clearances and separation. ^b The actual working voltage may exceed the value given in the table by up to 10 %. NOTE 1 Values for creepage distances are derived from IEC 60664-1 based on pollution degree 2. NOTE 2 Under a conformal coating. See 4.5.					

Annex I (informative)

Application, installation, and testing considerations for Level of Protection “ec” asynchronous machines

I.1 Surface temperature

Research and testing have demonstrated that electrical machines of normal industrial designs operating at rated full-load steady-state conditions will not have excessive surface temperatures, and there is minimal risk of ignition of a flammable gas-air mixture release that has a mixture auto-ignition temperature of greater than 200 °C. Surface temperatures of electrical machines operating at rated load, seldom exceed 155 °C for the stator (i.e., Class F insulation hot spot temperature) and 200 °C (for large machines and high-efficiency small machines) to 300 °C (for lower-efficiency small machines) for the rotor. Air turbulence around the rotor components, while in operation, and rapid decay of rotor temperature as a rotor comes to a halt, greatly reduces the risk of ignition of all but materials with low auto-ignition temperatures. There has not been a demonstrated need to take special precautions for normal industrial designs of electrical machines due to surface temperature considerations for application in environments where the flammable gas environment requires equipment of temperature classes T1, T2, or T3 (i.e., temperature of 200 °C or greater).

Anti-condensation space heaters, mounted within the frames of electrical machines, can generally be designed to remain within the temperature classification of the machine; so additional high temperature assessment is generally not necessary.

Maximum surface temperature determination in accordance with IEC 60079-0 may not always require testing of every sample. Often, the test data resulting from the testing of prototypes can be extrapolated to cover additional machines in a series. In these cases, the test report should always clearly identify the tests that were omitted and the justification for omitting them.

Surface temperature measurements for the stator and rotor of motors may not be required for motors with assigned temperature classes T1, T2, or T3 with Thermal Class 105 (A) or 130 (B) in accordance with IEC 60085. Rotor surface temperature can be determined by calculation based upon manufacturer's experience or by prototype testing of representative samples with appropriate adjustment factors.

For rotor temperature determination of motors with assigned temperature classes T4, T5, or T6, non-destructive test methods can be used. These methods may include the use of the rotor-slip method, application of temperature-sensitive paints or stickers, or telemetry of measurements from temperature sensors that are temporarily mounted on the rotor. Rotor surface temperatures for similar designs can then be determined by calculation based upon manufacturer's experience or by prototype testing of representative samples with appropriate adjustment factors. Stator and bearing temperature determinations require separate consideration.

The service temperature determination of other components as defined in IEC 60079-0 may be required for items such as gaskets, cable glands (if included with the motor), etc.

I.2 Starting

Starting (acceleration) of an electrical machine is excluded as part of normal operation for a Level of Protection “ec” machine under duty S1, S2, S6, or S9, with no restrictions on the frequency of starting other than the requirement that the motor temperatures reach thermal equilibrium (cool) before re-starting. “Normal” operating conditions for electric machines are

assumed to be rated full-load steady conditions. Small motors with cast rotor cages present almost no risk of being an ignition source during the motor starting period. Large, high-speed motors of fabricated rotor cage construction present a higher risk of sparking within the air gap of the machine during a very brief period of the total starting sequence.

For Level of Protection “ec” machines of duty S3, S4, S5, S7, S8, or S10, the user of a Level of Protection “ec” machine should consider both the frequency of machine starting for the application and the potential consequence of an ignition event. Special measures such as pre-start ventilation or soft-starting; or even a machine employing a different type of protection, could be used to further reduce the risk of ignition.

I.3 Rated voltage and surface discharges

At the higher ratings of stator operating voltages, incendive surface discharges can occur, particularly if the stator end-winding surfaces are dirty. Since the corona discharge could potentially be a continuous ignition source, this effect must be considered during normal machine operation.

Industry experience is that properly maintained, form wound, electrical machines with rated voltages up to and including 6,6 kV phase-to-phase do not present an unacceptable risk of ignition in IIA or IIB atmospheres, due to winding surface discharges. For higher voltages, other constructions, or other atmospheres; an electrical machine specifically designed as a Level of Protection “ec” machine or a machine designed using another EPL Gc protection should be considered.

Annex J (informative)

Luminaires incorporating LEDs

J.1 LEDs for EPL Gb

A luminaire employing LEDs such as an LED package, or LED Module as the light source is not included in Level of Protection “eb”. However, such a design is possible in accordance with the type of protection requirements of IEC 60079-1, -2, -5, -6, -11, or -18 in EPL Gb.

If the type of protection 'intrinsic safety' is used, the requirements for Level of Protection “ib” are applied to the complete electrical circuit. Associated apparatus used to power the circuit would typically be protected by one of the other Gb types of protection other than “ib” and Level of Protection “eb”.

The connection facilities of the complete equipment in EPL Gb are given in Clauses 4 and 5.

NOTE There is a potential risk of ignition from optical radiation. Further guidance can be found in IEC 60079-28.

J.2 LEDs for EPL Gc

A luminaire employing an LED package, or LED Module as the light source is possible in Levels of Protection “ec”, “ic”, “nR”, and “mc”. If the type of protection 'intrinsic safety' is used, the requirements for Level of Protection “ic” are applied to the complete electrical circuit. Associated apparatus used to power the circuit would typically be protected by one of the other Gc Levels of Protection other than “ic” and “ec”.

The connection facilities of the complete equipment in EPL Gc are given in Clauses 4 and 5.

NOTE There is a potential risk of ignition from optical radiation. Further guidance can be found in IEC 60079-28.

Bibliography

IEC TS 60034-17, *Rotating electrical machines – Part 17: Cage induction motors when fed from converters – Application guide*

IEC 60034-18-41, *Rotating electrical machines – Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters – Qualification and quality control tests*

IEC TS 60034-25, *Rotating electrical machines – Part 25: AC electrical machines used in power drive systems*

IEC 60050 (all parts), *International Electrotechnical Vocabulary*

IEC 60050-411:1996, *International Electrotechnical Vocabulary – Chapter 411: Rotating machinery*

IEC 60050-426, *International Electrotechnical Vocabulary – Part 426: Equipment for explosive atmospheres*

IEC 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

IEC 60079-17, *Explosive atmospheres – Part 17: Electrical installations inspection and maintenance*

IEC 60079-18, *Explosive atmospheres – Part 18: Equipment protection by encapsulation "m"*

IEC 60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test methods and data*

IEC 60079-28, *Explosive atmospheres – Part 28: Protection of equipment and transmission systems using optical radiation*

IEC 60079-29-2, *Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

IEC 60079-30-2, *Explosive atmospheres – Part 30-2: Electrical resistance trace heating – Application guide for design, installation and maintenance*

IEC 60079-35-1, *Explosive atmospheres – Part 35-1: Caplights for use in mines susceptible to firedamp – General requirements – Construction and testing in relation to the risk of explosion*

IEC 60086-1, *Primary batteries – Part 1: General*

IEC 60095-1, *Lead-acid starter batteries – Part 1: General requirements and methods of test*

IEC 60364-5-55, *Electrical installations of buildings – Part 5-55: Selection and erection of electrical equipment – Other equipment*

IEC 60622, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Sealed nickel-cadmium prismatic rechargeable single cells*

IEC 60623, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells*

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

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

IEC 60927, *Auxiliaries for lamps – Starting devices (other than glow starters) – Performance requirements*

IEC TR 60943, *Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals*

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

IEC 61056-1, *General purpose lead-acid batteries (valve-regulated types) – Part 1: General requirements, functional characteristics – Methods of test*

IEC 61347-2-1, *Lamp controlgear – Part 2-1: Particular requirements for starting devices (other than glow starters)*

IEC 61347-2-4, *Lamp controlgear – Part 2-4: Particular requirements for DC supplied electronic ballasts for general lighting*

IEC 61347-2-7, *Lamp controlgear – Part 2-7: Particular requirements for battery supplied electronic controlgear for emergency lighting (self-contained)*

IEC 61347-2-8, *Lamp controlgear – Part 2-8: Particular requirements for ballasts for fluorescent lamps*

IEC 61347-2-9, *Lamp controlgear – Part 2-9: Particular requirements for electromagnetic controlgear for discharge lamps (excluding fluorescent lamps)*

IEC 61347-2-13, *Lamp controlgear – Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules*

IEC 61951-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Portable sealed rechargeable single cells – Part 1: Nickel-cadmium*

IEC 62013-1, *Caplights for use in mines susceptible to firedamp – Part 1: General requirements – Construction and testing in relation to the risk of explosion*

IEEE 1349:2011, *IEEE Guide for the Application of Electric Motors in Class I, Division 2 and Class I, Zone 2 Hazardous (Classified) Locations*

ISO 13849-1, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

ANSI/UL 746B, *Polymeric Materials – Long Term Property Evaluations*

ANSI/UL 746C, *Polymeric materials – Use in electrical equipment evaluations*

EN 954-1, *Safety of machinery – Safety related parts of control systems – Part 1: General principles for design*

API RP2216:2003, *Ignition risk of hydrocarbon liquids and vapors by hot surfaces in the open air*

BREDTHAUER, J., STRUCK, N. *Starting of large medium voltage motors – design, protection, and safety aspects*, IEEE Transactions of Industry Applications, Vol. 31, No. 5, pp. 1167-1176, September/October 1995¹

DYMOND, J. H. *Stall time, acceleration time, frequency of starting: the myths and the facts*, IEEE Transactions Industrial Applications, Vol. 29, No. 1, pp. 42-51, January/February 1993¹

IEEE Paper No. PCIC-2005-31, D. E. Delaney and M. K. Bruin, *Surface Temperature Test Methods Per IEEE 1349*, IEEE Transactions on Industry Applications, Vol. 43, No. 3, May/June 2007, pp. 821-828

IEEE Paper No. PCIC-98-03, P. S. Hamer, B. M. Wood, R. L. Doughty, R. L. Gravell, R. C. Hasty, S. E. Wallace, and J. O. Tsao, *Flammable Vapor Ignition by Hot Rotor Surfaces Within an Induction Motor – Reality or Not?*, IEEE Transactions on Industry Applications, Vol. 35, No. 1, Jan/Feb 1999, pp. 100-113

¹ Refer to this paper for discussions of locked-rotor temperature calculations.

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch