BSI Standards Publication

Explosive atmospheres

Part 0: Equipment – General requirements (IEC 60079-0:2017)

bsi.

National foreword

This British Standard is the UK implementation of EN IEC 60079-0:2018. It is identical to IEC 60079-0:2017. It supersedes BS EN 60079-0:2012+A11:2013, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EXL/31, Equipment for explosive atmospheres.

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

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

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Date	Text affected

EUROPEAN STANDARD

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EN IEC 60079-0

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English Version

Explosive atmospheres - Part 0: Equipment - General requirements (IEC 60079-0:2017)

Atmosphères explosives - Partie 0: Matériel - Exigences générales
(IEC 60079-0:2017)

Explosionsgefährdete Bereiche - Teil 0: Betriebsmittel - Allgemeine Anforderungen
(IEC 60079-0:2017)

This European Standard was approved by CENELEC on 2017-12-04. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document (31/1345/FDIS), future edition 7 of IEC 60079-0, prepared by IEC/TC 31 "Equipment for explosive atmospheres" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60079-0:2018.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2019-01-06
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2021-07-06

This document supersedes EN 60079-0:2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

Endorsement notice

The text of the International Standard IEC 60079-0:2017 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC/TS 60034-25	NOTE	Harmonized as CLC/TS 60034-25.
IEC 60034-29	NOTE	Harmonized as EN 60034-29.
IEC 60079-2	NOTE	Harmonized as EN 60079-2.
IEC 60079-5	NOTE	Harmonized as EN 60079-5.
IEC 60079-6	NOTE	Harmonized as EN 60079-6.
IEC 60079-7	NOTE	Harmonized as EN 60079-7.
IEC 60079-10-1	NOTE	Harmonized as EN 60079-10-1.
IEC 60079-10-2	NOTE	Harmonized as EN 60079-10-2.
IEC 60079-11	NOTE	Harmonized as EN 60079-11.
IEC 60079-13	NOTE	Harmonized as EN 60079-13.
IEC 60079-14	NOTE	Harmonized as EN 60079-14.
IEC 60079-15	NOTE	Harmonized as EN 60079-15.
IEC 60079-17	NOTE	Harmonized as EN 60079-17.
IEC 60079-18	NOTE	Harmonized as EN 60079-18.
IEC 60079-19	NOTE	Harmonized as EN 60079-19.
IEC 60079-25	NOTE	Harmonized as EN 60079-25.
IEC 60079-28	NOTE	Harmonized as EN 60079-28.
IEC 60079-29-1	NOTE	Harmonized as EN 60079-29-1.

IEC 60079-29-4	NOTE	Harmonized as EN 60079-29-4.
IEC/IEEE 60079-30-1	NOTE	Harmonized as EN 60079-30-1.
IEC 60079-31	NOTE	Harmonized as EN 60079-31.
IEC/TS 60079-32-1	NOTE	Harmonized as CLC/TR 60079-32-1.
IEC/TS 60079-39	NOTE	Harmonized as CLC/TS 60079-39 [1]).
IEC 60254 (series)	NOTE	Harmonized in EN 60254 series.
IEC 60623	NOTE	Harmonized as EN 60623.
IEC 60896-11	NOTE	Harmonized as EN 60896-11.
IEC 60896-21	NOTE	Harmonized as EN 60896-21.
IEC 60952 (series)	NOTE	Harmonized in EN 60952 series.
IEC 61056-1	NOTE	Harmonized in EN 61056-1.
IEC 61427 (series)	NOTE	Harmonized in EN 61427 series.
IEC 61951-1	NOTE	Harmonized as EN 61951-1.
IEC 61951-2	NOTE	Harmonized as EN 61951-2.
IEC 61960 (series)	NOTE	Harmonized in EN 61960 series.
ISO/IEC 80079-20-2	NOTE	Harmonized as EN ISO/IEC 80079-20-2.
ISO/IEC 80079-34	NOTE	Harmonized as EN ISO/IEC 80079-34.
ISO/IEC 80079-36	NOTE	Harmonized as EN ISO/IEC 80079-36.
ISO/IEC 17000	NOTE	Harmonized as EN ISO/IEC 17000.

[1]) Under preparation. Stage at the time of publication: CLC/FprTS 60079-39:2017.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

Publication	Year	Title	EN/HD	Year
IEC 60034-1	-	Rotating electrical machines - Part 1: Rating and performance	EN 60034-1 [2])	-
IEC 60034-5	-	Rotating electrical machines - Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) - Classification	EN 60034-5	2001
IEC 60079-1	-	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"	EN 60079-1	2014
IEC 60079-20-1	-	Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data	EN 60079-20-1	2010
IEC 60079-26	-	Explosive atmospheres - Part 26: Equipment with equipment protection level (EPL) Ga	EN 60079-26	2015
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	EN 60079-35-1	2011
			+AC	2011
IEC 60086-1	-	Primary batteries - Part 1: General	EN 60086-1	2015
IEC 60192	-	Low pressure sodium vapour lamps - Performance specifications	EN 60192	2001
IEC 60216-1	-	Electrical insulating materials - Thermal endurance properties - Part 1: Ageing procedures and evaluation of test results	EN 60216-1	2013
IEC 60216-2	-	Electrical insulating materials - Thermal endurance properties - Part 2: Determination of thermal endurance properties of electrical insulating materials - Choice of test criteria	EN 60216-2	2005
IEC 60243-1	-	Electric strength of insulating materials - Test methods - Part 1: Tests at power frequencies	EN 60243-1	2013
IEC 60423	-	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for conduits and fittings	EN 60423	2007
IEC 60529	-	Degrees of protection provided by enclosures (IP Code)	EN 60529	1991
			+EN 60529:1991/corrigendum May 1993	1993

[2]) Under preparation. Stage at the time of publication: FprEN 60034-1:2017.

IEC 60662 (mod)	-	High pressure sodium vapour lamps - Performance specifications	EN 60662	2012
			+prAA	2017
IEC 60664-1	-	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests	EN 60664-1	2007
IEC 60947-1	-	Low-voltage switchgear and controlgear - Part 1: General rules	EN 60947-1	2007
IEC 62626-1	-	Low-voltage switchgear and controlgear enclosed equipment - Part 1: Enclosed switch outside the scope of IEC 60947-3 for various applications, to provide isolation of electrical equipment during repair and maintenance work	EN 62626-1	2014
ISO 48	-	Rubber, vulcanized or thermoplastic_- Determination of hardness (hardness between 10 IRHD and 100 IRHD)	-	-
ISO 178	-	Plastics - Determination of flexural properties	EN ISO 178	2010
ISO 179	series	Plastics - Determination of Charpy impact properties	EN ISO 179	series
ISO 262	-	ISO general purpose metric screw threads- Selected sizes for screws, bolts and nuts	-	-
ISO 273	-	Fasteners - Clearance holes for bolts and screws	EN 20273	1991
ISO 527-2	-	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics	EN ISO 527-2	2012
ISO 965-1	-	ISO general purpose metric screw threads - Tolerances – Part 1: Principles and basic data	-	-
ISO 965-3	-	ISO general purpose metric screw threads- Tolerances – Part 3: Deviations for constructional screw threads	-	-
ISO 3601-1	-	Fluid power systems - O-rings – Part 1: Inside diameters, cross-sections, tolerances and designation codes	-	-
ISO 3601-2	-	Fluid power systems - O-rings - Part 2: Housing dimensions for general applications	-	-
ISO 4014	-	Hexagon head bolts - Product grades A and B	EN ISO 4014	2011
ISO 4017	-	Fasteners - Hexagon head screws - Product grades A and B	EN ISO 4017	2014
ISO 4026	-	Hexagon socket set screws with flat point	EN ISO 4026	2003
ISO 4027	-	Hexagon socket set screws with cone point	EN ISO 4027	2003
ISO 4028	-	Hexagon socket set screws with dog point	EN ISO 4028	2003
ISO 4029	-	Hexagon socket set screws with cup point	EN ISO 4029	2003
ISO 4032	-	Hexagon regular nuts (style 1) - Product grades A and B	EN ISO 4032	2012
ISO 4762	-	Hexagon socket head cap screws	EN ISO 4762	2004
ISO 4892-2	-	Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps	EN ISO 4892-2	2013
ISO 7380	-	Hexagon socket button head screws	EN ISO 7380	2011
ISO 14583	-	Hexalobular socket pan head screws	EN ISO 14583	2011
ANSI/UL 746B	-	Polymeric Materials - Long-Term Property Evaluations	-	-
ANSI/UL 746C	-	Standard for Polymeric Materials - Use in Electrical Equipment Evaluations	-	-
ASTM D 5964	-	Standard Practice for Rubber IRM 901, IRM 902, and IRM 903 Replacement Oils for ASTM No. 1, ASTM No. 2, ASTM No. 3 Oils, and IRM 905 formerly ASTM No. 5 Oil	-	-

Annex ZY
(informative)

Additional Information relating to the European ATEX Directive 2014/34/EU

ZY.1 Equipment Groups and Categories

In all cases Equipment Protection Levels (EPL) as defined by EN IEC 60079-0 are related to the corresponding Equipment Groups and Equipment Categories according to table ZY.1. The same applies if a standard makes reference to the intended use of equipment in Zones according to the definitions in EN 60079-10-1 and EN 60079-10-2.

Table ZY.1

EN IEC 60079-0		*Directive 2014/34/EU*		*EN 60079-10-X*
EPL	***Group***	***Equipment Group***	***Equipment Category***	***Zones***
Ma	*I*	*I*	*M1*	*Not Applicable*
Mb			*M2*	
Ga	*II*	*II*	*1G*	*0*
Gb			*2G*	*1*
Gc			*3G*	*2*
Da	*III*		*1D*	*20*
Db			*2D*	*21*
Dc			*3D*	*22*

ZY.2 Instructions

The manufacturer or his authorized representative in the Community is to draw up the instructions for use in the required Community languages.

In clause 30.1 under: “instructions for safety addressing the following areas – installation and erection;”

“Information other than the general requirements given in IEC 60079-14”

Is replaced by

“Information other than the general requirements given in EN 60079-14 and EN 50628”

NOTE EN 50628 - Erection of electrical installations in underground mines

ZY.3 Marking

ZY.3.1

The marking according to this standard is to be supplemented by the marking according to Directive 2014/34/EU. Examples are given below.

European marking examples

Directive part	**Standard part**	**Equipment example**
⟨Ex⟩ **I M2**	**Ex db I Mb**	Mining equipment,

Type of Protection flameproof enclosure “d”

II 2G	**Ex eb IIB T4 Gb**	Gas explosion protected equipment Type of Protection increased safety “e”
II 1D	**Ex ma IIIC 120°C Da**	Dust explosion protected equipment, Type of Protection encapsulation “m”

NOTE 1 Attention is drawn to the requirement in 29.3 f):

“The Ex marking for explosive gas atmospheres and explosive dust atmospheres shall be separate and not combined;”

II 1 G Ex ia IIB T4 Ga

II 1 D Ex ia IIIC T120°C Da

Alternatively, the directive part of the marking may be combined and the standard part of the marking kept separate, as follows:

II 1 GD Ex ia IIB T4 Ga
Ex ia IIIC T120°C Da

NOTE 2 For Ex Equipment intended to be put on the market in the EEA, CE marking is applicable. For Ex Components intended to be put on the market in the EEA, CE marking is not applicable.

ZY.3.2

Contrary to 29.3 a) the marking is to always include the manufacturer’s name (not trademark) and address. The address is to be sufficient to identify the physical location of the manufacturer. An address used for postal purposes, without identifying the physical location, is not sufficient.

ZY.4 Fans

Clause 17.2.5 “Room ventilating fans” is to be supplemented by the requirements given in EN 14986 “Design of fans working in potentially explosive atmospheres”

ZY.5 Significant changes between this European Standard and EN 60079-0:2012+A11:2013

This European Standard supersedes EN 60079-0:2012+A11:2013.

Table ZY.2 – Significant changes with respect to EN 60079-0:2012+A11:

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Throughout document, “electrical equipment” replaced by “equipment” where appropriate.	Multiple	X		
Scope List of “Type of “Protection” and “Product” standards combined into one list.	1	X		
Definitions used in multiple sub-parts added. Definitions harmonized across sub-parts and added to 60079-0 where appropriate. Battery definitions updated	3	X		

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Clarification of the way that information on process temperature influences can be expressed.	5.1.2	X		
Clarification regarding the determination of service temperatures when dust layers are present	5.2	X		
Clarification on the need to provide service temperature information for Ex Components in the Schedule of Limitations	5.2	X		
Relocation of EPL Da dust layer requirements from IEC 60079-18 & IEC 60079-31	5.3.2.3.1	A1		
Clarified that for EPL Db, a maximum specified dust layer of greater than 200 mm is not permitted as thicker layers have no additional effect on maximum surface temperature.	b)	X		
Added for EPL Db, a dust layer in a specified orientation, marked as T_L	c)		X	
Clarified that for EPL Dc, no dust layer tests are required.	5.3.2.3.3	X		
Clarified that the “temperature” is the temperature of the air surrounding the component	5.3.3	X		
Subdivided section dealing with higher permitted surface temperatures for “smooth” surfaces. Corrected area from 1 000 mm^2 to 10 000 mm^2.	5.3.4	X		
Clarified that the “Ex” requirements of IEC 60079 supplement those of the relevant industrial standards.	6.1	X		
Added requirement that where an adhesive is used to secure a gasket, it shall be used within its COT and shall comply with the requirements for cements.	6.5			C1
Requirements relocated to IEC 60079-28	former 6.6.2	A2		
Ultrasonic requirements updated based on latest research work	6.6.3		X	
Added reference to IEC 60079-28	6.6.4	A2		
Material identification parameters have been revised to reflect reasonably obtainable information	7.1.2.2	X		
“RTI-mechanical” has been clarified to include “RTI-mechanical strength” and “RTI-mechanical impact”	7.1.2.2	X		
Material identification parameters have been revised to reflect reasonably obtainable information	7.1.2.3	X		
Relocated information on “cements” from Clause 12.	7.1.2.4	X		
“RTI-mechanical” has been clarified to include “RTI-mechanical strength” and “RTI-mechanical	7.2.2	X		

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
impact". Requirements for cements aligned with the requirements for elastomers.				
Relocation of 10 K margin for EPL Gc or Dc from IEC 60079-15, IEC 60079-18 & IEC 60079-31	7.2.2	A3		
Added clarification with respect to gaskets and seals where only the outer edge is potentially exposed to light.	7.3	X		
Clarification added that one or more of the described techniques may be used	7.4.2	X		
Added additional relaxation for the case where a surface is in contact with an earthed surface on only two of four sides.	7.4.2 b)		X	
Added reference to IEC 60243-1 and IEC 60243-2 for test method to require a 4 kV DC test.	7.4.2.c)			C2
Additional guidance added with respect to the possible Specific Conditions of Use	7.4.2 e)	X		
New option added for portable, mains-powered equipment with earth-connected guard	7.4.2 f)		X	
Added option for determination of maximum transferred charge.	7.4.2 g) Table 10		X	
Added missing limits (same as 7.4.2)	7.4.3 a)	X		
Clarified that it is a dc test that is conducted	7.4.3 b)	X		
Clarified that this requirement is not applied to personal or portable equipment	7.5	X		
Clarified Group I limits	8.2	X		
Clarified Group II, EPL Ga limits	8.3	X		
Added limitation for external surfaces of >65% copper	8.5			C3
Added clarification as to what is considered a tool	9.1	X		
Clarified that the tolerance class of the set screw is not critical, only that it not protrude from the threaded hole after tightening.	9.4	X		
Information on cements transferred to Clause 7	12	X		
Required that Ex Component Certificates require a Schedule of Limitations in all cases	13.5		X	
Revised to clarified that all connection facilities may not be a "Compartment".	14	X		
Sub-clause split to separate the requirements for protective earthing and equipotential bonding into separate sections	15.3 15.4	X		
Section split to separate secureness of electrical connections from the internal earth continuity plate.	15.6 15.7	X		
Non-threaded Group I cable glands are no longer required to be Ex Components.	16.3		X	
Non-threaded Group I blanking elements are no	16.4		X	

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
longer required to be Ex Components.				
Scope of Clause 17 clarified to define applicability	17	X		
Additional guidance notes added to address bearings	17.3	X		
Clarified applicability to disconnectors, interlocks, and maintenance switches.	18.2	X		
Fuse requirements deleted as they are addressed in the individual sub-parts	19	X		
Added requirements for EPL Gc and Dc	20.1			C4
The test circuit requirements for a flameproof connection have been removed as they are more completely specified in IEC 60079-1.	20.2	X		
The impact test requirements for luminaires are relocated to Table 15	21.1 Table 15	X		
Clarified interlock switch operation for flameproof luminaires	21.2	X		
Clarified that some Types of Protection permit connection of cells in parallel	23.2	X		
New cell types and data added based on latest available data	Table 13		X	
New cell types and data added based on latest available data	Table 14			C5
Clarification of what documentation is to be prepared regarding the explosion safety aspects of the equipment	24	X		
Clarification that the type tests are to take into consideration the installation instructions	26.2	X		
Clarification that the “glass” requirements also apply to “ceramic” parts	26.4.1.1	X		
Added a permission to interchange the order of tests at the “lower test temperature” and the “upper test temperature”.	26.4.1.2.2 26.4.1.2.3	X		
Clarified the construction of the impact test fixture	26.4.2	X		
Clarified the impact tests for glass parts	26.4.2	X		
Added clarification to deal with the new IPX9 ratings	26.4.5.1		X	
Clarified the test voltage for maximum surface temperature	26.5.1.3	X		
Relocation of EPL Da dust layer requirements from IEC 60079-18 & IEC 60079-31	26.5.1.3	A1		
Relocation of EPL Db specified dust layer requirements from IEC 60079-31	26.5.1.3	A4		
Added for EPL Db, a dust layer in a specified orientation, marked as T_{L}	26.5.1.3		B1	

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Clarified that for EPL Dc, the testing is conducted without a dust layer.	26.5.1.3	X		
Relocation of thermal endurance to heat 10K relaxation for Gc equipment from IEC 60079-15, IEC 60079-18, & IEC 60079-31	Table 17	X		
Clarification of a consistent way to address elastomeric materials exposed to ultraviolet light	26.10	X		
Replacement of “oil No. 2” with the revised designation of “oil IRM 902”.	26.11	X		
Option added for testing at lower voltages when low resistance materials are encountered	26.13		X	
Transferred charge test added based on IEC TS 60079-32-2	26.17		X	
The reference to a specific instruction document instead of an “X” condition relocated to e) instead of a note giving a permission	29.3 e)	X		
Updated to reflect the additional levels of protection already shown in the sub-parts: “da”, “dc”, “eb”, “ec”, “oc”, “op is”, “op pr”, “op sh”, “pxb”, “pyb”, “pzc”, “qb”, “sa”, “sb”, and “sc”.	29.4 b)	X		
Text added to address marking of “Ex associated equipment”	29.4		X	
Updated to reflect the additional levels of protection already shown in the sub-parts: “ic”, “op is”, “op pr”, “op sh”, “pxb”, “pyb”, “pzc”, “sa”, “sb”, and “sc”.	29.5 b)	X		
Clarified marking of EPL Da, EPL Db with no dust layer, EPL Db with a specified dust layer, and EPL Dc.	29.5 d)	X		
Introduced marking for EPL Db with a dust layer in a specified orientation	29.5 d)		X	
Text added to address marking of “Ex associated equipment”	29.5		X	
Text added to address marking of equipment intended to be installed in a boundary wall.	29.9		X	
The marking of Ex Component enclosure was aligned with the marking requirements of IEC 60079-1 and IEC 60079-7	29.10	X		
The alternate marking of EPL has been deleted.	former 29.13			C6
Marking for electric machines operated with a converter clarified	29.15	X		
Instruction material guidance clarified	30.1	X		
Additional instruction material for electric machines added	30.3			C7
Additional instruction material for cable glands added	30.5 A.5			C8

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Allow ISO 10807 hose assemblies to be used with cable glands.	A.1		X	
Clarify testing with stainless steel mandrels	A.3	X		
Reduction of the time / slippage permitted	A.3.1.1		X	
Clarify impact testing of cable glands	A.3.3 Figure A.3	X		
Clarified the order of tests	A.3.4	X		
Clarified remarks	Annex B	X		
Aligned Figure with text	Figure C.1	X		
Clarified operation of electric machines from converters	Annex D (informative)	X		
Clarified temperature testing of electric machines	Annex E (informative)	X		
Flowchart for Cable Gland testing	Annex G (informative)	X		
Guidance of electric machine shaft voltages	Annex H (informative)	X		

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. More guidance may be found by referring to the Redline Version of the standard.

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

A1 The dust layer requirements for EPL Da are unchanged from what previously existed in IEC 60079-18, Ed 4 and IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

A2 IEC 60079-28 now includes all requirements for optical radiation for all EPLs.

A3 The COT requirements for EPL Gc or Dc are unchanged from what previously existed in IEC 60079-15, Ed 4, IEC 60079-18, Ed 4, and IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

A4 The dust layer requirements for EPL Db with a specified dust layer depth are unchanged from what previously existed in IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

B1 Dust layer requirements for EPL Db with a dust layer in a specified orientation have been added.

C1 It is recognized that the new requirements were, in many cases, already applied. The change is to ensure that they are uniformly and consistently applied.

C2 Require that the test be conducted at 4 kV DC.

C3 The limitation applies to external surfaces of other than cable glands, blanking elements, thread adapters and bushings.

C4 The added requirements for tool securing and marking are consistent with the approach in IEC 60079-15

C5 Voltage values were changed following additional research due to the complicated assessment and sometimes unspecified construction of Li/Ion-cells. It was found that some voltage values previously stated were too low.

C6 The now required EPL marking may be other than that permitted by the Level of Protection to account for limiting restrictions of material or plastic material surface area.

C7 Additional instruction material for electric machines required to facilitate selection, installation, and maintenance.

C8 Additional instruction material for cable glands required to facilitate selection and installation.

Annex ZZ
(informative)

Relationship between this European Standard and the Essential Requirements of 2014/34/EU [2014 OJ L96] aimed to be covered

This European Standard has been prepared under a Commission's standardisation request M/BC/CEN/92/46 to provide one voluntary means of conforming to Essential Requirements of 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive, and associated EFTA regulations.

Table ZZ.1 – Correspondence between this European Standard and Annex II of Directive 2014/34/EU [2014 OJ L96]

Essential Requirements of 2014/34/EU	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.0.1.	Entire standard	Second indent only
1.0.2.	Entire standard including Annex ZY	By reference to appropriate EPLs
1.0.3.	3.84 and related references throughout document	In particular, use of "X" marking and related Specific Conditions of Use for Ex Equipment or Schedule of Limitations for Ex Components
1.0.4.	5 / 6.1	
1.0.5.	28.3 / 29 / Annex ZY	
1.0.6.	30	
1.1.1.	7 / 8	
1.1.2.	8.5	
1.1.3.	6.3 / 7 / 8	
1.2.1.	Entire standard	
1.2.2.	Entire standard	
1.2.3.	Not covered	
1.2.4.	5.3.2.3	
1.2.5.	Not covered	
1.2.6.	6.3	
1.2.7.	6.1	
1.2.8.	Not covered	
1.2.9.	Not covered	See EN 60079-1

Essential Requirements of 2014/34/EU	Clause(s) / sub-clause(s) of this EN	Remarks / Notes
1.3.1.	(in part) 5 / 6.6	
1.3.2.	7.4	
1.3.3.	6.4	
1.3.4.	Not covered	See EN ISO 80079-36
1.3.5.	Not covered	
1.4.1.	6.1	
1.4.2.	6.1	
1.5.	Not covered	
1.6.1.	Not covered	
1.6.2.	Not covered	
1.6.3.	Not covered	
1.6.4.	15 / Annex A	
1.6.5.	Not covered	
2.0.1.	Throughout document	Multiple requirements for Group I, EPL Ma
2.0.2.	Throughout document	Multiple requirements for Group I, EPL Mb
2.1.1.	Throughout document	Multiple requirements for Group II, EPL Ga
2.1.2.	Throughout document	Multiple requirements for Group III, EPL Da
2.2.1.	Throughout document	Multiple requirements for Group II, EPL Gb
2.2.2	Throughout document	Multiple requirements for Group III, EPL Db
2.3.1.	Throughout document	Multiple requirements for Group II, EPL Gc
2.3.2.	Throughout document	Multiple requirements for Group III, EPL Dc
3.	Not covered	

NOTE To confer a presumption of conformity with the relevant essential requirements of Directive 2014/34/EU, this standard has to be applied together with at least one of the supplemental standards giving the requirements for a specific Type of Protection. See Clause 1.

WARNING 1: Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2: Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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EXPLOSIVE ATMOSPHERES –

Part 0: Equipment – General requirements

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60079-0 has been prepared by IEC technical committee 31: Equipment for explosive atmospheres.

This seventh edition cancels and replaces the sixth edition, published in 2011. This edition constitutes a technical revision.

The significance of the changes between IEC Standard, IEC 60079-0, Edition 6 (2011) and IEC 60079-0, Edition 7 (2017) are as listed below:

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Throughout document, “electrical equipment” replaced by “equipment” where appropriate.	Multiple	X		
Scope List of “Type of “Protection” and “Product” standards combined into one list.	1	X		
Definitions used in multiple sub-parts added. Definitions harmonized across sub-parts and added to 60079-0 where appropriate. Battery definitions updated	3	X		
Clarification of the way that information on process temperature influences can be expressed.	5.1.2	X		
Clarification regarding the determination of service temperatures when dust layers are present	5.2	X		
Clarification on the need to provide service temperature information for Ex Components in the Schedule of Limitations	5.2	X		
Relocation of EPL Da dust layer requirements from IEC 60079-18 & IEC 60079-31	5.3.2.3.1	A1		
Clarified that for EPL Db, a maximum specified dust layer of greater than 200 mm is not permitted as thicker layers have no additional effect on maximum surface temperature.	b)	X		
Added for EPL Db, a dust layer in a specified orientation, marked as T_L	c)		X	
Clarified that for EPL Dc, no dust layer tests are required.	5.3.2.3.3	X		
Clarified that the “temperature” is the temperature of the air surrounding the component	5.3.3	X		
Subdivided section dealing with higher permitted surface temperatures for “smooth” surfaces. Corrected area from 1 000 mm^2 to 10 000 mm^2.	5.3.4	X		
Clarified that the “Ex” requirements of IEC 60079 supplement those of the relevant industrial standards.	6.1	X		
Added requirement that where an adhesive is used to secure a gasket, it shall be used within its COT and shall comply with the requirements for cements.	6.5			C1
Requirements relocated to IEC 60079-28	former 6.6.2	A2		
Ultrasonic requirements updated based on latest research work	6.6.3		X	
Added reference to IEC 60079-28	6.6.4	A2		
Material identification parameters have been revised to reflect reasonably obtainable information	7.1.2.2	X		
“RTI-mechanical” has been clarified to include “RTI-mechanical strength” and “RTI-mechanical impact”	7.1.2.2	X		
Material identification parameters have been revised to reflect reasonably obtainable information	7.1.2.3	X		
Relocated information on “cements” from Clause 12.	7.1.2.4	X		
“RTI-mechanical” has been clarified to include “RTI-mechanical strength” and “RTI-mechanical impact”. Requirements for cements aligned with the requirements for elastomers.	7.2.2	X		

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Relocation of 10 K margin for EPL Gc or Dc from IEC 60079-15, IEC 60079-18 & IEC 60079-31	7.2.2	A3		
Added clarification with respect to gaskets and seals where only the outer edge is potentially exposed to light.	7.3	X		
Clarification added that one or more of the described techniques may be used	7.4.2	X		
Added additional relaxation for the case where a surface is in contact with an earthed surface on only two of four sides.	7.4.2 b)		X	
Added reference to IEC 60243-1 and IEC 60243-2 for test method to require a 4 kV DC test..	7.4.2.c)			C2
Additional guidance added with respect to the possible Specific Conditions of Use	7.4.2 e)	X		
New option added for portable, mains-powered equipment with earth-connected guard	7.4.2 f)		X	
Added option for determination of maximum transferred charge.	7.4.2 g) Table 10		X	
Added missing limits (same as 7.4.2)	7.4.3 a)	X		
Clarified that it is a dc test that is conducted	7.4.3 b)	X		
Clarified that this requirement is not applied to personal or portable equipment	7.5	X		
Clarified Group I limits	8.2	X		
Clarified Group II, EPL Ga limits	8.3	X		
Added limitation for external surfaces of >65% copper	8.5			C3
Added clarification as to what is considered a tool	9.1	X		
Clarified that the tolerance class of the set screw is not critical, only that it not protrude from the threaded hole after tightening.	9.4	X		
Information on cements transferred to Clause 7	12	X		
Required that Ex Component Certificates require a Schedule of Limitations in all cases	13.5		X	
Revised to clarified that all connection facilities may not be a “Compartment”.	14	X		
Sub-clause split to separate the requirements for protective earthing and equipotential bonding into separate sections	15.3 15.4	X		
Section split to separate secureness of electrical connections from the internal earth continuity plate.	15.6 15.7	X		
Non-threaded Group I cable glands are no longer required to be Ex Components.	16.3		X	
Non-threaded Group I blanking elements are no longer required to be Ex Components.	16.4		X	
Scope of Clause 17 clarified to define applicability	17	X		
Additional guidance notes added to address bearings	17.3	X		
Clarified applicability to disconnectors, interlocks, and maintenance switches.	18.2	X		
Fuse requirements deleted as they are addressed in the individual sub-parts	19	X		
Added requirements for EPL Gc and Dc	20.1			C4

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
The test circuit requirements for a flameproof connection have been removed as they are more completely specified in IEC 60079-1.	20.2	X		
The impact test requirements for luminaires are relocated to Table 15	21.1 Table 15	X		
Clarified interlock switch operation for flameproof luminaires	21.2	X		
Clarified that some Types of Protection permit connection of cells in parallel	23.2	X		
New cell types and data added based on latest available data	Table 13		X	
New cell types and data added based on latest available data	Table 14			C5
Clarification of what documentation is to be prepared regarding the explosion safety aspects of the equipment	24	X		
Clarification that the type tests are to take into consideration the installation instructions	26.2	X		
Clarification that the “glass” requirements also apply to “ceramic” parts	26.4.1.1	X		
Added a permission to interchange the order of tests at the “lower test temperature” and the “upper test temperature”.	26.4.1.2.2 26.4.1.2.3	X		
Clarified the construction of the impact test fixture	26.4.2	X		
Clarified the impact tests for glass parts	26.4.2	X		
Added clarification to deal with the new IPX9 ratings	26.4.5.1		X	
Clarified the test voltage for maximum surface temperature	26.5.1.3	X		
Relocation of EPL Da dust layer requirements from IEC 60079-18 & IEC 60079-31	26.5.1.3	A1		
Relocation of EPL Db specified dust layer requirements from IEC 60079-31	26.5.1.3	A4		
Added for EPL Db, a dust layer in a specified orientation, marked as T_L	26.5.1.3		B1	
Clarified that for EPL Dc, the testing is conducted without a dust layer.	26.5.1.3	X		
Relocation of thermal endurance to heat 10K relaxation for Gc equipment from IEC 60079-15, IEC 60079-18, & IEC 60079-31	Table 17	X		
Clarification of a consistent way to address elastomeric materials exposed to ultraviolet light	26.10	X		
Replacement of “oil No. 2” with the revised designation of “oil IRM 902”.	26.11	X		
Option added for testing at lower voltages when low resistance materials are encountered	26.13		X	
Transferred charge test added based on IEC TS 60079-32-2	26.17		X	
The reference to a specific instruction document instead of an “X” condition relocated to e) instead of a note giving a permission	29.3 e)	X		
Updated to reflect the additional levels of protection already shown in the sub-parts: “da”, “dc”, “eb”, “ec”, “oc”, “op is”, “op pr”, “op sh”, “pxb”, “pyb”, “pzc”, “qb”, “sa”, “sb”, and “sc”.	29.4 b)	X		

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Text added to address marking of “Ex associated equipment”	29.4		X	
Updated to reflect the additional levels of protection already shown in the sub-parts: “ic”, “op is”, “op pr”, “op sh”, “pxb”, “pyb”, “pzc”, “sa”, “sb”, and “sc”.	29.5 b)	X		
Clarified marking of EPL Da, EPL Db with no dust layer, EPL Db with a specified dust layer, and EPL Dc.	29.5 d)	X		
Introduced marking for EPL Db with a dust layer in a specified orientation	29.5 d)		X	
Text added to address marking of “Ex associated equipment”	29.5		X	
Text added to address marking of equipment intended to be installed in a boundary wall.	29.9		X	
The marking of Ex Component enclosure was aligned with the marking requirements of IEC 60079-1 and IEC 60079-7	29.10	X		
The alternate marking of EPL has been deleted.	former 29.13			C6
Marking for electric machines operated with a converter clarified	29.15	X		
Instruction material guidance clarified	30.1	X		
Additional instruction material for electric machines added	30.3			C7
Additional instruction material for cable glands added	30.5 A.5			C8
Allow ISO 10807 hose assemblies to be used with cable glands.	A.1		X	
Clarify testing with stainless steel mandrels	A.3	X		
Reduction of the time / slippage permitted	A.3.1.1		X	
Clarify impact testing of cable glands	A.3.3 Figure A.3	X		
Clarified the order of tests	A.3.4	X		
Clarified remarks	Annex B	X		
Aligned Figure with text	Figure C.1	X		
Clarified operation of electric machines from converters	Annex D (informative)	X		
Clarified temperature testing of electric machines	Annex E (informative)	X		
Flowchart for Cable Gland testing	Annex G (informative)	X		
Guidance of electric machine shaft voltages	Annex H (informative)	X		

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. More guidance may be found by referring to the Redline Version of the standard.

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

A1 The dust layer requirements for EPL Da are unchanged from what previously existed in IEC 60079-18,Ed 4 and IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

A2 IEC 60079-28 now includes all requirements for optical radiation for all EPLs.

A3 The COT requirements for EPL Gc or Dc are unchanged from what previously existed in IEC 60079-15, Ed 4, IEC 60079-18, Ed 4, and IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

A4 The dust layer requirements for EPL Db with a specified dust layer depth are unchanged from what previously existed in IEC 60079-31, Ed 2, but have been relocated to IEC 60079-0 to allow consistent application in all Types of Protection.

B1 Dust layer requirements for EPL Db with a dust layer in a specified orientation have been added.

C1 It is recognized that the new requirements were, in many cases, already applied. The change is to ensure that they are uniformly and consistently applied.

C2 Require that the test be conducted at 4 kV DC.

C3 The limitation applies to external surfaces of other than cable glands, blanking elements, thread adapters and bushings.

C4 The added requirements for tool securing and marking are consistent with the approach in IEC 60079-15

C5 Voltage values were changed following additional research due to the complicated assessment and sometimes unspecified construction of Li/Ion-cells. It was found that some voltage values previously stated were too low.

C6 The now required EPL marking may be other than that permitted by the Level of Protection to account for limiting restrictions of material or plastic material surface area.

C7 Additional instruction material for electric machines required to facilitate selection, installation, and maintenance.

C8 Additional instruction material for cable glands required to facilitate selection and installation.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
31/1345/FDIS	31/1356/RVD

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

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

A list of all parts of the 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

EXPLOSIVE ATMOSPHERES –

Part 0: Equipment – General requirements

1 Scope

This part of IEC 60079 specifies the general requirements for construction, testing and marking of Ex Equipment and Ex Components intended for use in explosive atmospheres.

The standard atmospheric conditions (relating to the explosion characteristics of the atmosphere) under which it may be assumed that Ex Equipment can be operated are:

- temperature –20 °C to +60 °C;
- pressure 80 kPa (0,8 bar) to 110 kPa (1,1 bar); and
- air with normal oxygen content, typically 21 % v/v.

This part of IEC 60079 and other standards supplementing this standard specify additional test requirements for Ex Equipment operating outside the standard temperature range, but further additional consideration and additional testing may be required for Ex Equipment operating outside the standard atmospheric pressure range and standard oxygen content. Such additional testing may be particularly relevant with respect to Types of Protection that depend on quenching of a flame such as 'flameproof enclosures "d"' (IEC 60079-1) or limitation of energy, 'intrinsic safety "i"' (IEC 60079-11).

NOTE 1 Although the standard atmospheric conditions above give a temperature range for the atmosphere of -20 °C to +60 °C, the normal ambient temperature range for the Ex Equipment is –20 °C to +40 °C, unless otherwise specified and marked. See 5.1.1. It is considered that –20 °C to +40 °C is appropriate for many items of Ex Equipment and that to manufacture all Ex Equipment to be suitable for a standard atmosphere upper ambient temperature of +60 °C would place unnecessary design constraints.

NOTE 2 Requirements given in this standard result from an ignition hazard assessment made on equipment. The ignition sources taken into account are those found associated with this type of equipment, such as hot surfaces, electromagnetic radiation, mechanically generated sparks, mechanical impacts resulting in thermite reactions, electrical arcing and static electric discharge in normal industrial environments.

NOTE 3 Where an explosive gas atmosphere and a combustible dust atmosphere are, or can be, present at the same time, the simultaneous presence of both often warrants additional protective measures. Additional guidance on the use of Ex Equipment in hybrid mixtures (mixture of a flammable gas or vapour with a combustible dust or combustible flyings) is given in IEC 60079-14.

IEC 60079 does not specify requirements for safety, other than those directly related to the explosion risk.

Ignition sources like adiabatic compression, shock waves, exothermic chemical reaction, self-ignition of dust, naked flames and hot gases/liquids, are not addressed by this standard.

NOTE 4 Although outside the scope of this standard, such equipment would typically be subjected to a hazard analysis that identifies and lists all of the potential sources of ignition by the equipment and the measures to be applied to prevent them becoming effective. See ISO/IEC 80079-36.

This document is supplemented or modified by the following parts and technical specifications:

– IEC 60079-1: Gas – Flameproof enclosures "d";
– IEC 60079-2: Gas and dust – Pressurized enclosure "p";
– IEC 60079-5: Gas – Powder filling "q";
– IEC 60079-6: Gas – Liquid immersion "o";
– IEC 60079-7: Gas – Increased safety "e";

– IEC 60079-11: Gas and dust – Intrinsic safety "i";
– IEC 60079-13: Gas and dust – Equipment protection by pressurized room “p” & artificially ventilated room “v”;
– IEC 60079-15: Gas – Type of protection “n”;
– IEC 60079-18: Gas and dust – Encapsulation "m";
– IEC 60079-25: Gas and dust – Intrinsically safe electrical systems
– IEC 60079-26: Gas – Equipment with equipment protection level (EPL) Ga
– IEC 60079-28: Gas and dust – Protection of equipment and transmission systems using optical radiation
– IEC 60079-29-1: Gas detectors – Performance requirements of detectors for flammable gases
– IEC 60079-29-4: Gas detectors – Performance requirements of open path detectors for flammable gases
– IEC/IEEE 60079-30-1: Gas and dust – Electrical resistance trace heating – General and testing requirements.
– IEC 60079-31: Dust – Protection by enclosure “t”
– IEC 60079-33: Gas and dust – Special protection “s”
– IEC 60079-35-1: Caplights for use in mines susceptible to firedamp – General requirements – Construction and testing in relation to the risk of explosion
– IEC TS 60079-39: Gas – Intrinsically safe systems with electronically controlled spark duration limitation
– IEC TS 60079-40: Gas – Requirements for process sealing between flammable process fluids and electrical systems
– ISO 80079-36: Gas and dust – Non-electrical equipment for explosive atmospheres – Basic method and requirements

This document, along with the additional parts of IEC 60079 mentioned above, is not applicable to the construction of

- electromedical apparatus,
- shot-firing exploders,
- test devices for exploders, and
- shot-firing circuits.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

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

IEC 60079-20-1, *Explosive atmospheres – Part 20-1: Material characteristics for gas and vapour classification – Test methods and data*

IEC 60079-26, *Explosive atmospheres – Part 26: Equipment with Equipment Protection Level (EPL) Ga*

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 60192, *Low-pressure sodium vapour lamps – Performance specifications*

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 60243-1, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

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

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

IEC 60662, *High-pressure sodium vapour lamps – Performance specifications*

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 62626-1, *Low-voltage switchgear and controlgear enclosed equipment – Part 1: Enclosed switch-disconnectors outside the scope of IEC 60947-3 to provide isolation during repair and maintenance work*

ISO 48, *Rubber, vulcanized or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 178, *Plastics – Determination of flexural properties*

ISO 179 (all parts), *Plastics – Determination of Charpy impact properties*

ISO 262, *ISO general-purpose metric screw threads – Selected sizes for screws, bolts and nuts*

ISO 273, *Fasteners – Clearance holes for bolts and screws*

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

ISO 965-1, *ISO general-purpose metric screw threads – Tolerances – Part 1: Principles and basic data*

ISO 965-3, ISO *general-purpose metric screw threads – Tolerances – Part 3: Deviations for constructional screw threads*

ISO 3601-1, *Fluid power systems – O-rings – Part 1: Inside diameters, cross-sections, tolerances and designation codes*

ISO 3601-2, *Fluid power systems – O-rings – Part 2: Housing dimensions for general applications*

ISO 4014, *Hexagon head bolts – Product grades A and B*

ISO 4017, *Hexagon head screws – Product grades A and B*

ISO 4026, *Hexagon socket set screws with flat point*

ISO 4027, *Hexagon socket set screws with cone point*

ISO 4028, *Hexagon socket set screws with dog point*

ISO 4029, *Hexagon socket set screws with cup point*

ISO 4032, *Hexagon nuts, style 1 – Product grades A and B*

ISO 4762, *Hexagon socket head cap screws*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 7380, *Hexagon socket button head screws*

ISO 14583, *Hexalobular socket pan head screws*

ANSI/UL 746B, *Polymeric Materials – Long-Term Property Evaluations*

ANSI/UL 746C, *Polymeric Materials – Used in Electrical Equipment Evaluations*

ASTM D5964, *Standard practice for rubber IRM 901, IRM 902, and IRM 903 replacement oils for ASTM No. 1, ASTM No. 2, and ASTM No. 3*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426.

3.1
ambient temperature
temperature of the air or other media, in the immediate vicinity of the equipment or component

Note 1 to entry: This does not refer to the temperature of any process media, unless the equipment or component is totally immersed in the process media. See 5.1.1.

Note 2 to entry: If Ex Equipment or an Ex Component is located inside or adjacent to another piece of equipment, the “ambient temperature” is the temperature of the air or other media surrounding the Ex Equipment or Ex Component and may be higher than the ambient air surrounding the complete equipment due to the additional heat dissipated within the complete equipment.

Note 3 to entry: The ambient temperature referred to in the IEC 60079 series is only related to the explosion safety of the Ex Equipment or Ex Component.

3.2
area, hazardous
area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment

3.3
area, non-hazardous
area in which an explosive atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment

3.4
associated apparatus
electrical apparatus which contains both intrinsically safe and non-intrinsically safe circuits and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits

Note 1 to entry: Associated apparatus is either:

a) additionally protected by a Type of Protection suitable for use in the appropriate explosive atmosphere, or

b) not protected by a Type of Protection suitable for use in the appropriate explosive atmosphere and therefore is not to be used within an explosive atmosphere

3.5
Ex associated equipment
auxiliary equipment used in conjunction with explosion-protected equipment to maintain specific aspects of the Type of Protection of the explosion-protected equipment

Note 1 to entry: Examples include special time/current relays for increased safety motors, pressurization control systems, power limits for encapsulated Ex Equipment, and the like.

Note 2 to entry: Ex associated equipment is either:

a) additionally protected by a Type of Protection suitable for use in the appropriate explosive atmosphere; or

b) not protected by a Type of Protection suitable for use in the appropriate explosive atmosphere and therefore is not to be used within an explosive atmosphere,

Note 3 to entry: A similar concept is applied to intrinsic safety where it is referred to as “associated apparatus”. See 3.4. A single piece of equipment may include both Ex associated equipment and associated apparatus.

3.6
auto-ignition temperature
AIT
lowest temperature (of a surface) at which, under specified conditions (according to IEC 60079-20-1), an ignition of a flammable gas or vapour in mixture with air or air/inert gas occurs

3.7
cells and batteries

3.7.1
battery
one or more cells fitted with devices necessary for use, for example, terminals, marking and protective devices

Note 1 to entry: See Figure 1 for examples of typical battery constructions.

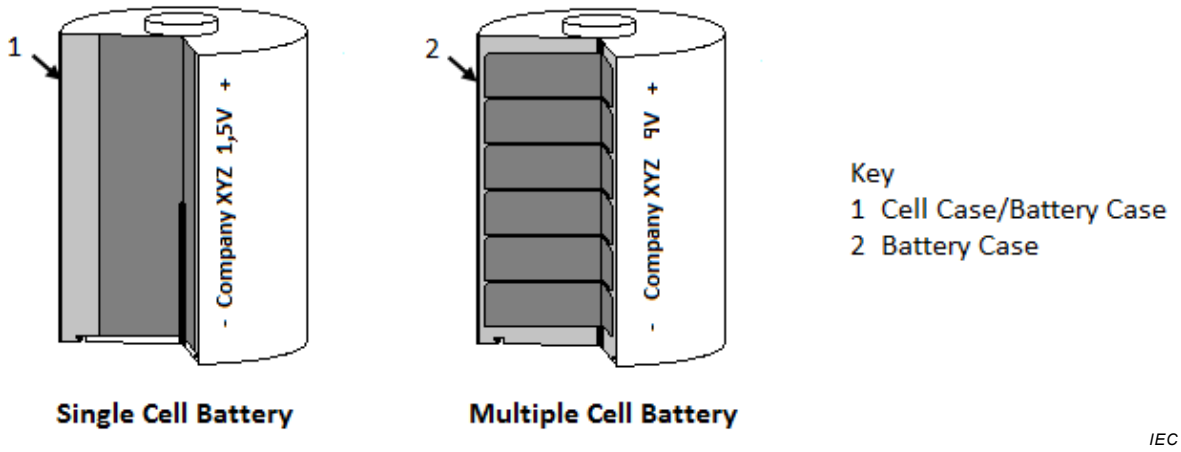


Figure 1 – Typical battery examples

3.7.2
capacity
electric charge which a battery or cell can deliver under specified discharge conditions

Note 1 to entry: The SI unit for electric charge, or quantity of electricity, is the coulomb (1 C = 1 A × s) but in practice, capacity is usually expressed in ampere hours (Ah).

3.7.3
cell
basic functional unit, consisting of an assembly of electrodes, electrolyte, case, terminals and usually separators, that is a source of electric energy obtained by direct conversion of chemical energy

Note 1 to entry: See primary cell and secondary cell.

3.7.4
charging
operation during which a secondary cell or battery is supplied with electric energy from an external circuit which results in chemical changes within the cell and thus the storage of energy as chemical energy

3.7.5
deep discharge
event which reduces a cell voltage below that recommended by the cell or battery manufacturer

3.7.6
maximum open-circuit voltage
<cell or battery>
voltage of a new primary battery or of a fully charged secondary battery when the discharge current is zero

Note 1 to entry: See Table 13 and Table 14 which show the maximum open-circuit voltage for acceptable cells.

3.7.7
nominal voltage
<cell or battery>
suitable approximate value of the voltage used to designate or identify a cell or battery or an electrochemical system

3.7.8
vented cell or battery
secondary cell, or battery, having a cover provided with an opening through which gaseous products may escape

3.7.9
primary cell or battery
cell or battery which is not designed to be electrically recharged

3.7.10
reverse charging
act of forcing current through either a primary cell or secondary cell in the same direction as the normal flow, generally due to the reverse polarity in an expired cell of a series connected battery

3.7.11
sealed cell
secondary cell which remains closed and does not release either gas or liquid when operated within the limits specified by the cell 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.

3.7.12
valve-regulated cell or battery
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.

3.7.13
secondary cell or battery
cell which is designed to be electrically recharged

Note 1 to entry: The recharge is accomplished by way of a reversible chemical reaction.

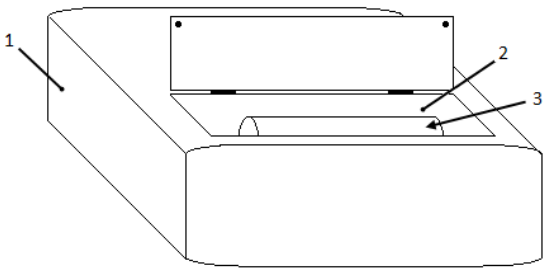
3.7.14
battery compartment
compartment of the equipment that accommodates one or more cells and batteries

Note 1 to entry: The battery compartment is an integral part of the equipment.

Note 2 to entry: A battery compartment may be a battery container

3.7.15
battery container
enclosure to contain one or more cells or batteries

Note 1 to entry: See Figure 2 for examples of typical battery constructions.



Key
1 Equipment
2 Battery Compartment
3 Cell/Battery/Replaceable Battery Pack

IEC

Figure 2 – Typical battery compartment

3.7.16
battery case
cell case
cell or battery enclosure that is an integral part of the construction of the cell or battery

Note 1 to entry: The case can be sealed, valve-regulated, or vented.

3.7.17
replaceable battery pack
assembly consisting of one or more interconnected cells, along with any integrated protective components, which form a complete replaceable battery

Note 1 to entry: See Figure 3 for examples of typical replaceable battery pack construction.

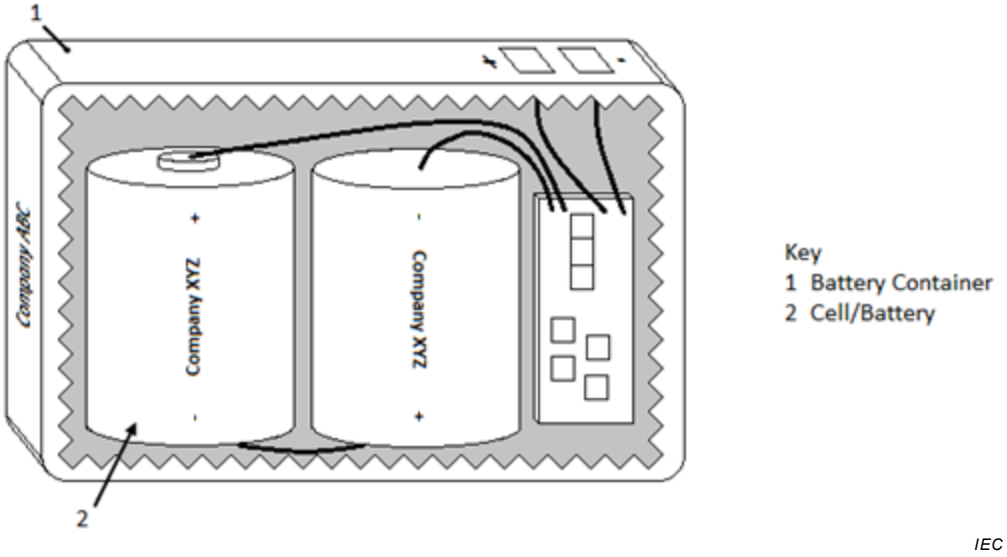


Figure 3 – Typical replaceable battery pack

3.8
breathing device
device which permits an exchange between the atmosphere within an enclosure and the surrounding atmosphere and which maintains the integrity of the Type of Protection

3.9
bushing
device carrying one or more conductors, insulated or bare, through an internal or external wall of an enclosure

3.10
cable gland
device permitting the introduction of one or more electric or fibre optic cables into an electrical Ex Equipment enclosure so as to maintain the relevant Type of Protection and provide a degree of strain relief

Note 1 to entry: See Figure A.1 for illustration of the terms used for cable glands.

3.10.1
clamping device
<cable gland>
element of a cable gland for preventing tension or torsion in the cable from being transmitted to the connections

3.10.2
compression element
<cable gland>
element of a cable gland compressing or displacing the sealing ring

3.10.3
sealing ring
<cable gland>
element used in a cable gland to ensure the sealing between the cable gland and the cable

3.10.4
Ex Equipment cable gland
<cable gland>
cable gland tested separately from the equipment enclosure but having an Ex Equipment certificate and which is intended to be fitted to an Ex Equipment enclosure

Note 1 to entry: This does not preclude an Ex Component certificate for cable glands.

3.10.5
cable transit device
<cable gland>
an entry device, intended for one or more electric or fibre optic cables, with a seal made up of one or more separate elastomeric modules or parts of modules (modular internal seal), which are compressed together when the device is assembled and mounted as intended

Note 1 to entry: Cable transit devices serve as Ex Equipment Blanking Elements when the elastomeric modules provided allow for this function.

3.11
casting
<non-metallic compound>
process of pouring a liquid compound at normal ambient pressure into a cast

3.12
certificate
document that conveys the assurance of the conformity of a product, process, system, person, or organization with specified requirements

Note 1 to entry: The certificate is either the supplier's declaration of conformity or the purchaser's recognition of conformity or certification (as a result of action by a third party) as defined in ISO/IEC 17000.

3.12.1
Ex Component Certificate
certificate prepared for an Ex Component (see 3.36)

3.12.2
Ex Equipment Certificate
certificate prepared for Ex Equipment

3.13
coating
material applied to a surface

3.14
conformal coating
electrical insulating material applied as a coating to loaded printed circuit boards to produce a thin layer conforming to the surface in order to provide a protective barrier against deleterious effects from environmental conditions

3.15
compound
<for encapsulation>
any thermosetting, thermoplastic, epoxy resin or elastomeric materials with or without fillers and/or additives, in their solid state

3.16
conduit entry
means of introducing a conduit into Ex Equipment so as to maintain the relevant Type of Protection

3.17
connection facilities
terminals, screws or other parts, used for the electrical connection of conductors

3.18
connections, factory
terminations intended for connection during a manufacturing process under controlled conditions

3.19
connections, field-wiring
terminations intended for connection by the installer in the field

3.20
continuous operating temperature
COT
temperature range which ensures the stability and integrity of the material for the expected life of the equipment, or part, in its intended application

3.21
converter
<for use with electric machines>
unit for electronic power conversion, changing one or more electrical characteristics and comprising one or more electronic switching devices and associated components, such as transformers, filters, commutation aids, controls, protections, and auxiliaries, if any

Note 1 to entry: A converter is also known by other terms. For example, a frequency converter, a converter drive, an inverter drive, a variable speed drive, an adjustable speed drive (ASD), or a variable frequency drive (VFD).

3.21.1
converter, soft-start
<for use with electric machines>
converter which limits the input current to the electric machine during the starting process

Note 1 to entry: It is intended that the soft-start converter is used only during the starting process and is then isolated from the power system or bypassed when the electric machine is running.

3.22
degree of protection of enclosure
IP
numerical classification according to IEC 60529 or IEC 60034-5 (as applicable) preceded by the symbol IP applied to the enclosure of equipment to provide:

– protection of persons against contact with, or approach to, live parts and against contact with moving parts (other than smooth rotating shafts and the like) inside the enclosure,

– protection of the equipment against ingress of solid foreign objects, and

– where indicated by the classification, protection of the equipment against harmful ingress of water

Note 1 to entry: The detailed test requirements for rotating electric machines are in IEC 60034-5.

Note 2 to entry: The enclosure which provides the degree of protection IP is not necessarily the same as the equipment enclosure providing the Type of Protection listed in Clause 1.

Note 3 to entry: An enclosure which provides the degree of protection required by one of the types of protection listed in Clause 1 will have been subjected to other tests prior to the tests for degree of protection. See 26.4.

3.23
draining device
device which permits liquids to flow out from an enclosure and which maintains the integrity of the Type of Protection

3.24
dust
generic term including both combustible dust and combustible flyings

3.24.1
combustible dust
finely divided solid particles, 500 µm or less in nominal size, which may form explosive mixtures with air at standard atmospheric pressure and temperatures

Note 1 to entry: This includes dust and grit as defined in ISO 4225.

Note 2 to entry: The term solid particles is intended to address particles in the solid phase and not the gaseous or liquid phase, but does not preclude a hollow particle.

3.24.1.1
conductive dust
combustible dust with electrical resistivity equal to or less than 1 kΩ·m

Note 1 to entry: ISO/IEC 80079-20-2 contains the test method for determining the electrical resistivity of dusts.

3.24.1.2
non-conductive dust
combustible dust with electrical resistivity greater than 1 kΩ·m

Note 1 to entry: ISO/IEC 80079-20-2 contains the test method for determining the electrical resistivity of dusts.

3.24.2
combustible flyings
solid particles, including fibres, where one dimension is greater than 500 µm in nominal size, which may form an explosive mixture with air at standard atmospheric pressure and temperature

Note 1 to entry: One dimension has a high ratio when compared to the other two dimensions

Note 2 to entry: Examples of flyings include carbon fibre, rayon, cotton (including cotton linters and cotton waste) sisal, jute, hemp, cocoa fibre, oakum and baled waste kapok.

3.25
dust-tight enclosure
enclosure capable of excluding the ingress of observable dust particle deposits

3.26
dust-protected enclosure
enclosure in which the ingress of dust is not totally excluded, but is unlikely to enter in sufficient quantity to interfere with the safe operation of the equipment and does not accumulate in a position within the enclosure where it is liable to cause an ignition hazard

3.27
duty cycle
repetitive variation of load in which the cycle time is too short for thermal equilibrium to be attained in the first cycle

[SOURCE: IEC 60050-411:1996, 411-51-7]

3.28
elastomer
a macromolecular material which returns rapidly to approximately its initial dimensions and shape after substantial deformation by a weak stress and release of the stress

Note 1 to entry: The definition applies to room temperature test conditions.

[SOURCE: IEC 60050-212:2010, 212-14-05]

3.29
encapsulation
process of applying a compound to enclose an electrical device(s) by suitable means

3.30
enclosure
all the walls, doors, covers, cable glands, rods, spindles, shafts, etc. which contribute to the Type of Protection or the degree of protection IP of the equipment

3.31
equipment
general term including apparatus, fittings, devices, components, and the like used as a part of, or in connection with, an installation

3.31.1
equipment, electrical
items applied as a whole or in part for the utilization of electrical energy

Note 1 to entry: These include, amongst others, items for the generation, transmission, distribution, storage, measurement, regulation, conversion and consumption of electrical energy and items for telecommunications.

3.31.2
equipment, fixed
equipment fastened to a support, or otherwise secured in a specific location when energized

3.31.3
equipment, personal
equipment intended to be worn by and in contact with a person’s body during operation

3.31.4
equipment, portable
equipment intended to be carried by a person during operation

Note 1 to entry: Portable equipment carried by a person during operation is sometimes referred to as hand-held equipment.

3.31.5
equipment, transportable
equipment not intended to be carried by a person during operation nor intended for fixed installation

3.32
equipment grouping
classification system of equipment related to the explosive atmosphere for which they are intended to be used

Note 1 to entry: IEC 60079-0 identifies three equipment groups:

Group I, equipment for mines susceptible to fire damp;

Group II, which is divided into sub-groups, equipment for all places with an explosive gas atmosphere other than mines susceptible to fire damp

Group III, which is divided into sub-groups, equipment for all places with an explosive dust atmosphere other than mines susceptible to fire damp

3.33
Equipment Protection level
EPL
Level of Protection assigned to equipment based on its likelihood of becoming a source of ignition and distinguishing the differences between explosive gas atmospheres, explosive dust atmospheres, and the explosive atmospheres in mines susceptible to firedamp

3.33.1
EPL Ma
equipment for installation in a mine susceptible to firedamp, having a "very high" Level of Protection, which has sufficient security that it is unlikely to become an ignition source in normal operation, during expected malfunctions or during rare malfunctions, even when left energized in the presence of an outbreak of gas

3.33.2
EPL Mb
equipment for installation in a mine susceptible to firedamp, having a "high" Level of Protection, which has sufficient security that it is unlikely to become a source of ignition in normal operation or during expected malfunctions in the time span between there being an outbreak of gas and the equipment being de-energized

3.33.3
EPL Ga
equipment for explosive gas atmospheres, having a "very high" Level of Protection, which is not a source of ignition in normal operation, during expected malfunctions or during rare malfunctions

3.33.4
EPL Gb
equipment for explosive gas atmospheres, having a "high" Level of Protection, which is not a source of ignition in normal operation or during expected malfunctions

3.33.5
EPL Gc
equipment for explosive gas atmospheres, having an "enhanced" Level of Protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp)

3.33.6
EPL Da
equipment for explosive dust atmospheres, having a "very high" Level of Protection, which is not a source of ignition in normal operation, during expected malfunctions, or during rare malfunctions

3.33.7
EPL Db
equipment for explosive dust atmospheres, having a "high" Level of Protection, which is not a source of ignition in normal operation or during expected malfunctions

3.33.8
EPL Dc
equipment for explosive dust atmospheres, having an "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp)

3.34
Ex Equipment blanking element
blanking element tested separately from the Ex Equipment enclosure but having an Ex Equipment certificate and which is intended to be fitted to an Ex Equipment enclosure

Note 1 to entry: This does not preclude an Ex Component certificate for blanking elements.

3.35
Ex Equipment thread adapter
thread adapter tested separately from the Ex Equipment enclosure but having an Ex Equipment certificate and which is intended to be fitted to an Ex Equipment enclosure

Note 1 to entry: This does not preclude an Ex Component certificate for thread adapters.

3.36
Ex Component
equipment intended to be part of Ex Equipment, marked with the symbol “U”, which is not intended to be used alone, and requires additional consideration when incorporated into Ex Equipment

3.37
Ex Equipment
explosion-protected equipment

Note 1 to entry: Such equipment often includes Ex Components, but additional evaluation is always required as part of their incorporation into equipment.

3.38
explosive atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapour, or dust which, after ignition, permits self-sustaining propagation

3.39
explosive dust atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of dust, which, after ignition, permits self-sustaining propagation

3.40
explosive gas atmosphere
mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, which, after ignition, permits self-sustaining flame propagation

3.41
explosive test mixture
specified explosive mixture used for the testing of equipment for explosive gas atmospheres

3.42
fault, countable
fault which occurs in parts of electrical equipment conforming to the constructional requirements of the standard for the Type of Protection being considered

3.43
fault, non-countable
fault which occurs in parts of electrical apparatus not conforming to the constructional requirements of the standard for the Type of Protection being considered

3.44
firedamp
flammable mixture of gases naturally occurring in a mine

Note 1 to entry: Firedamp consists mainly of methane, but always contains small quantities of other gases, such as nitrogen, carbon dioxide, and hydrogen, and sometimes ethane and carbon monoxide. The terms firedamp and methane are used frequently in mining practice as synonyms.

3.45
free space
intentionally created space surrounding components or space inside components

3.46
fuse
a 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

3.47
galvanic isolation
arrangement within equipment which permits the transfer of signals or power between two circuits without any direct electrical connection between the two

Note 1 to entry: Galvanic isolation frequently utilizes either magnetic (transformer or relay) or opto-coupled elements.

3.48
gasket
compressible element provided in a joint of an enclosure to provide a degree of protection against the ingress of solid foreign objects or against the ingress of water

3.49
gas
gaseous state of a substance that cannot reach equilibrium with its liquid or solid state in the temperature and pressure range of interest

Note 1 to entry: This is a simplification of the scientific definition, and merely requires that the substance is above its boiling point or sublimation point at the ambient temperature and pressure.

3.50
hybrid mixture
mixture of a flammable gas or vapour with a dust

Note 1 to entry: According to ISO/IEC 80079-20-2, the term “dust” is defined as including both combustible dust and combustible flyings

3.51
infallible separation
separation between electrically conductive parts, not considered as subject to short circuits, when in conformity with the “infallible” constructional requirements of the standard for the Type of Protection being considered

3.52
joint
place where the corresponding surfaces of two parts of an enclosure, or the conjunction of two enclosures, come together

3.53
Level of Protection
subdivision of a Type of Protection, correlating with the Equipment Protection Level, that differentiates the likelihood of the equipment becoming a source of ignition

Note 1 to entry: For example, Type of Protection intrinsic safety “i” is subdivided into Levels of Protection “ia”, “ib”, and “ic; which correlate with Equipment Protection Levels Ga, Gb, and Gc (for explosive gas atmospheres).

3.54
limiting temperature
maximum permissible temperature for equipment or parts of equipment equal to the lower of the two temperatures determined by:

a) the maximum surface temperature;

b) the thermal stability of the materials used

3.55
lower flammable limit
LFL
concentration of flammable gas or vapour in air below which an explosive gas atmosphere does not form (see IEC 60079-20-1)

Note 1 to entry: For the purposes of Ex Equipment, this was previously referred to as the lower explosive limit (LEL).

Note 2 to entry: The concentration may be expressed as either a volume fraction or a mass per unit volume.

3.56
malfunction
situation where equipment or components do not perform their intended function with respect to explosion protection

Note 1 to entry: For the purposes of this standard this can happen due to a variety of reasons, including:

– failure of one (or more) of the component parts of the equipment or components;

– external disturbances (e.g. shocks, vibration, electromagnetic fields);

– design error or deficiency (e.g. software errors);

– disturbance of the power supply or other services;

– loss of control by the operator (especially for portable equipment).

Note 2 to entry: Some earlier editions of the Type of Protection standards referred to a “malfunction” as a “fault”.

3.56.1
malfunction, expected
disturbances or equipment malfunctions which normally occur in practice

3.56.2
malfunction, rare
type of malfunction, which may happen, but only in rare instances

Note 1 to entry: Two independent expected malfunctions which, separately, would not create a source of ignition, but which, in combination, do create a source of ignition, are regarded as a single rare malfunction

3.57
maximum surface temperature
highest temperature which is attained in service under the most adverse conditions (but within the specified tolerances) by any part or surface of Ex Equipment

3.58
minimum ignition temperature of an explosive gas atmosphere
lowest temperature of a heated surface which, under specified conditions according to IEC 60079-20-1, will ignite a flammable substance in the form of a gas or vapour mixture with air

Note 1 to entry: This term and “Auto-Ignition Temperature” are often used interchangeably

3.59
minimum ignition temperature of a dust layer
lowest temperature of a hot surface at which ignition occurs in a dust layer under specified test conditions

Note 1 to entry: The ignition temperature of a dust layer may be determined by the test method given in ISO/IEC 80079-20-2.

3.60
minimum ignition temperature of a dust cloud
lowest temperature of a hot surface on which the most ignitable mixture of the dust with air is ignited under specified test conditions

Note 1 to entry: The ignition temperature of a dust cloud may be determined by the test method given in ISO/IEC 80079-20-2.

3.61
mist
liquid released through a small opening, at temperatures below its flash point, resulting in extremely small droplets forming a cloud

3.62
normal operation
operation of equipment conforming electrically and mechanically with its design specification and used within the limits specified by the manufacturer

Note 1 to entry: The limits specified by the manufacturer may include persistent operational conditions, e.g. operation on a duty cycle.

Note 2 to entry: Variation of the supply voltage within stated limits and any other operational tolerance is part of normal operation.

Note 3 to entry: For electric machines, normal operation is specified based on the duty type (S1…S10 per IEC 60034-1).

3.63
overvoltage category
numeral defining a transient overvoltage condition

Note 1 to entry: Overvoltage categories I, II, III and IV are used, see IEC 60664-1.

3.64
plastic
a material which contains as an essential ingredient a high polymer and which at some stage in its processing into finished products can be shaped by flow

Note 1 to entry: Elastomers, which are also shaped by flow, are not considered as plastics.

[SOURCE: IEC 60050-212:2010, 212-04-02]

3.65
pollution degree
numeral characterizing the expected pollution of the micro-environment

Note 1 to entry: Pollution degrees 1, 2, 3 and 4 are used, see IEC 60664-1.

3.66
propagating brush discharge
highly energetic electrostatic discharge from an insulating sheet, layer, or coating on a grounded conductive surface or from a material of high resistivity and high breakdown voltage with the two surfaces highly charged to opposite polarity

3.67
protective device
device provided to interrupt an electric circuit in case a parameter exceeds a predetermined value

Note 1 to entry: Parameters often include current, temperature, pressure flow etc.

3.68
pyrophoric substance
substance that ignites spontaneously on exposure to air (for example phosphorus) or water (for example potassium or sodium)

Note 1 to entry: Pyrophoric substances are outside the scope of IEC 60079-0

3.69
radio frequency
electromagnetic waves from 9 kHz to 60 GHz

3.69.1
continuous transmission
transmission where the duration of the pulse is greater than half of the thermal initiation time

3.69.2
pulsed transmission
transmission where the duration of the pulse is shorter than half of the thermal initiation time, but the time between two consecutive pulses is longer than three times the thermal initiation time

3.69.3
thermal initiation time
time (over which the threshold power is averaged) during which energy deposited by the spark accumulates in a small volume of gas around it without significant thermal dissipation

Note 1 to entry: For times shorter than the thermal initiation time the total energy deposited by the spark will determine whether or not ignition occurs. For increasingly longer times, the power or rate at which energy is deposited becomes the determining factor for ignition.

3.69.4
threshold energy
Z_{th}
for a pulsed radio-frequency discharge, the maximum energy of the single pulse which can be extracted from the receiving body

3.69.5
threshold power
P_{th}
effective output power of the transmitter multiplied by the antenna gain

Note 1 to entry: The gain is produced by an antenna concentrating radiation in a particular direction and is always related to a specified reference antenna

Note 2 to entry: The threshold power is considered to be equal to the Effective Isotropic Radiated Power (EIRP) per ITU-R BS.561-2.

3.69.6
antenna gain
gain produced by an antenna concentrating radiation in a particular direction

Note 1 to entry: The gain of antennas is frequently less than unity.

3.70
rated value
value, assigned generally by the manufacturer, for a specified operating condition of a component, device or apparatus

3.71
rated insulation voltage
RMS withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation

Note 1 to entry: The rated insulation voltage is not necessarily equal to the rated voltage of equipment which is primarily related to functional performance.

3.72
rating
set of rated values and operating conditions

3.73
recurring peak voltage
maximum peak value of periodic excursions of the voltage waveform resulting from distortions of an AC voltage or from AC components superimposed on a DC voltage

Note 1 to entry: Random overvoltages, for example due to occasional switching, are not considered as recurring peak voltages.

3.74
related drawing
drawing or document not listed in the certificate but linked to the schedule drawing, and used for example, for detailed manufacture of component parts

3.75
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

3.76
schedule drawing
drawing or document listed in the certificate or test report

3.77
separation element
mechanical element, inside the equipment, which separates different parts of the equipment with different EPLs

Note 1 to entry: A separation element consists of a mechanical partition wall, which may be combined with a flameproof joint or natural ventilation.

3.78
serviceable condition
condition which permits a replacement or reclaimed component part to be used without prejudice to the performance or explosion protection aspects of the equipment, with due regard to the schedule drawings, as applicable, in which such a component part is used

3.79
service temperature
maximum or minimum temperature reached at specific points of the equipment when the equipment is operating at rated conditions, including ambient temperature and any external sources of heating or cooling(see 5.2)

Note 1 to entry: Equipment may reach different service temperatures in different parts.

3.80
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 may 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.

3.81
spacings, electrical
separation distances between conductive parts at different electrical potentials

3.81.1
clearance
shortest distance in air between two conductive parts

3.81.2
creepage distance
shortest distance along the surface of a solid insulating material, in contact with air, between two conductive parts

3.81.3
distance through casting compound
shortest distance through a casting compound between two conductive parts

3.81.4
distance through solid insulation
shortest distance through solid insulation between two conductive parts

3.81.5
distance under coating
shortest distance between conductive parts along the surface of an insulating medium covered with insulating coating

3.82
special fastener
specific form of fastening device in accordance with IEC 60079-0

3.83
symbol “U”
suffix to the certificate number used to denote an Ex Component

Note 1 to entry: The symbol “U” is used to identify that the equipment is incomplete and is not suitable for installation without further evaluation.

3.84
symbol “X”
suffix to the certificate number used to denote Specific Conditions of Use for Ex Equipment

Note 1 to entry: The symbol “X” is used to provide a means of identifying that essential information for the installation, use, and maintenance of the equipment is contained within the certificate.

3.85
temperature class
classification system of Ex Equipment, based on its maximum surface temperature, related to the specific explosive gas atmosphere for which it is intended to be used

3.86
termination compartment
compartment containing connection facilities

3.87
test, routine
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

3.88
test, type
test of one or more devices made to a certain design to show that the design meets certain specifications

3.89
Type of Protection
specific measures applied to equipment to avoid ignition of a surrounding explosive atmosphere

3.90
upper flammable limit
UFL
concentration of flammable gas or vapour in air above which an explosive gas atmosphere does not form (see IEC 60079-20-1)

Note 1 to entry: For the purposes of Ex Equipment, this was previously referred to as the upper explosive limit (UEL).

Note 2 to entry: The concentration may be expressed as either a volume fraction or a mass per unit volume.

3.91
vapour
gaseous state of a substance that can reach equilibrium with its liquid or solid state in the temperature and pressure range of interest

Note 1 to entry: This is a simplification of the scientific definition, and merely requires that the substance is below its boiling point or sublimation point at the ambient temperature and pressure.

3.92
void
unintentional space created as a consequence of the encapsulation or filling process

3.93
working voltage
highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

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

4 Equipment grouping

4.1 General

Equipment for explosive atmospheres is divided into groups as shown in 4.2, 4.3, and 4.4:

4.2 Group I

Equipment of Group I is intended for use in mines susceptible to firedamp.

NOTE The types of protection for Group I take into account the ignition of both firedamp and coal dust along with enhanced physical protection for equipment used underground.

Equipment intended for mines where the atmosphere, in addition to firedamp, may contain significant proportions of other flammable gases (i.e. other than methane), shall be constructed and tested in accordance with the requirements relating to Group I and also to the subdivision of Group II corresponding to the other significant flammable gases.

4.3 Group II

Equipment of Group II is intended for use in areas with an explosive gas atmosphere other than mines susceptible to firedamp.

Equipment of Group II is subdivided according to the nature of the explosive gas atmosphere for which it is intended.

Group II subdivisions:

- IIA, a typical gas is propane;
- IIB, a typical gas is ethylene;
- IIC, typical gases are hydrogen and acetylene.

NOTE 1 This subdivision is based on the maximum experimental safe gap (MESG) or the minimum igniting current ratio (MIC ratio) of the explosive gas atmosphere in which the equipment may be installed. (See IEC 60079-20-1).

NOTE 2 For external non-metallic materials of equipment, the subdivision is based on the electrostatic charging risk for external surface areas (see 7.4.2).

NOTE 3 Equipment marked IIB is suitable for applications requiring Group IIA equipment. Similarly, equipment marked IIC is suitable for applications requiring Group IIA or Group IIB equipment.

4.4 Group III

Equipment of Group III is intended for use in areas with an explosive dust atmosphere other than mines susceptible to firedamp.

Equipment of Group III is subdivided according to the nature of the explosive dust atmosphere for which it is intended.

Group III subdivisions:

- IIIA: combustible flyings;
- IIIB: non-conductive dust;
- IIIC: conductive dust.

NOTE Equipment marked IIIB is suitable for applications requiring Group IIIA equipment. Similarly, equipment marked IIIC is suitable for applications requiring Group IIIA or Group IIIB equipment.

4.5 Equipment for a particular explosive gas atmosphere

The equipment may be tested for a particular explosive gas atmosphere. In this case, the information shall be recorded on the certificate and the equipment marked accordingly.

5 Temperatures

5.1 Environmental influences

5.1.1 Ambient temperature

Equipment designed for use in a normal ambient temperature range of –20 °C to +40 °C does not require marking of the ambient temperature range. However, equipment designed for use in other than this normal ambient temperature range is considered to be special. The marking shall then include either the symbol T_a or T_{amb} together with both the upper and lower ambient temperatures or, if this is impracticable, the symbol "X" shall be used to indicate specific conditions of use that include the upper and lower ambient temperatures. See item e) of 29.3 and Table 1.

NOTE The ambient temperature range is permitted to be a reduced range, e.g. $-5\ ^{o}C \leq T_{amb} \leq 15\ ^{o}C$.

Table 1 – Ambient temperatures in service and additional marking

Equipment	Ambient temperature in service	Additional marking
Normal	Maximum: +40 °C Minimum: –20 °C	None
Special	Specified by the manufacturer	T_a or T_{amb} with the special range, for example, $-30\ °C \leq T_a \leq +40\ °C$ or the symbol "X"

5.1.2 External source of heating or cooling

Where the equipment is intended to be physically connected to or influenced by a separate external source of heating or cooling, such as a heated or cooled process vessel or pipeline, the ratings of the external source shall be specified in the certificate and in the manufacturer's instructions.

NOTE 1 The external source of heating or cooling is frequently referred to as the "process temperature".

NOTE 2 The way in which these ratings are expressed will vary according to the nature of the source and the installation. For sources generally larger than the equipment, the maximum or minimum temperature will usually be sufficient. For sources generally smaller than the equipment, or for heat conduction through thermal insulation, the rate of heat flow may be appropriate. Alternatively, the rating is often expressed by specification of a temperature at a defined accessible point on the equipment.

NOTE 3 The influence of radiated heat may need to be considered on the final installation. See IEC 60079-14.

5.2 Service temperature

Where this standard, or the standard for the specific Type of Protection, requires the service temperature to be determined at any place in the equipment, the temperature shall be determined for the rating of the equipment when the equipment is subjected to maximum or minimum ambient temperature and, where relevant, the maximum rated external source of heating or cooling. Service temperature testing, when required, shall be in accordance with 26.5.1.

For EPL Da equipment, the same dust layer as applied in 5.3.2.3.1 shall be applied when determining the service temperature.

For EPL Db equipment with a layer of dust, the same dust layers as applied in b) or c) of 5.3.2.3.2, as applicable, shall be applied when determining the service temperature.

Where the temperature range of an Ex Component is dependent on the service temperature range of one or more of the materials of construction on which the Type of Protection depends, the permitted temperature range for the Ex Component shall be indicated in the Schedule of Limitations. See 13.5.

NOTE The rating of the electrical equipment includes the ambient temperature, the electrical supply and load, duty cycle or duty type, as assigned by the manufacturer, typically as shown in the marking.

5.3 Maximum surface temperature

5.3.1 Determination of maximum surface temperature

Maximum surface temperature shall be determined according to 26.5.1 considering the maximum ambient temperature and, where relevant, the maximum rated external source of heating.

5.3.2 Limitation of maximum surface temperature

5.3.2.1 Group I electrical equipment

For electrical equipment of Group I, the maximum surface temperature shall be specified in relevant documentation according to Clause 24.

This maximum surface temperature shall not exceed:

– 150 °C on any surface where coal dust can form a layer,

– 450 °C where coal dust is not likely to form a layer (i.e., inside of a dust-protected enclosure).

5.3.2.2 Group II electrical equipment

The maximum surface temperature determined (see 26.5.1) shall not exceed:

– the temperature class assigned (see Table 2), or

– the maximum surface temperature assigned, or

– if appropriate, the ignition temperature of the specific gas for which it is intended.

Table 2 – Classification of maximum surface temperatures for Group II electrical equipment

Temperature class	Maximum surface temperature °C
T1	≤ 450
T2	≤ 300
T3	≤ 200
T4	≤ 135
T5	≤ 100
T6	≤ 85

More than one temperature class may be established for different ambient temperatures and different external sources of heating and cooling.

5.3.2.3 Group III electrical equipment

5.3.2.3.1 Maximum surface temperature for EPL Da

The maximum surface temperature shall be determined **with** a layer depth of at least 200 mm of dust surrounding all sides of the equipment according to 26.5.1.

NOTE Dust depth of more than 200 mm does not give rise to a further temperature increase that would need to be taken into account.

5.3.2.3.2 Maximum surface temperature for EPL Db

The maximum surface temperature for EPL Db can be determined according to any one of the following three configurations.

a) Maximum surface temperature determined without a layer of dust for EPL Db.

   The maximum surface temperature determined without a layer of dust according to 26.5.1 shall not exceed the maximum surface temperature assigned.

b) Maximum surface temperature with respect to a specified layer of dust for EPL Db.

   In addition to the maximum surface temperature required in a) above, the maximum surface temperature may also be determined according to 26.5.1 for a specified layer depth, (maximum surface temperature marking prefix $T_{\text{specified layer depth}}$), of dust surrounding all sides of the equipment. The maximum specified layer depth shall not exceed 200 mm.

NOTE 1 Dust depth of more than 200 mm does not give rise to a further temperature increase.

c) Maximum surface temperature with respect to a layer of dust with a specified orientation of the equipment for EPL Db.

   If one or more specific orientations are given in the instructions, tests shall be carried out according to 26.5.1 with a layer of dust on the surfaces on which the dust can accumulate (for each orientation, (maximum surface temperature marking prefix T_{L}), and the certificate number shall include the suffix “X” to indicate this specific condition of use in accordance with item d) of 29.5.

NOTE 2 Additional information on the application of equipment where dust layers up to 50 mm may accumulate on the equipment is given in IEC 60079-14.

5.3.2.3.3 Maximum surface temperature determined without a layer of dust for EPL Dc

The maximum surface temperature determined **without** a layer of dust according to 26.5.1 shall not exceed the maximum surface temperature assigned.

5.3.3 Small component temperature for Group I or Group II electrical equipment

NOTE There is both theoretical and practical evidence to show that the smaller the heated surface, the higher the surface temperature required to ignite a given explosive atmosphere.

Small components, for example transistors or resistors, whose temperature exceeds that permitted for the temperature classification, shall be acceptable providing that they conform to one of the following:

a) when tested in accordance with 26.5.3, small components shall not cause ignition of the flammable mixture and any deformation or deterioration caused by the higher temperature shall not impair the Type of Protection; or

b) for T4 and Group I classification, small components shall conform to Table 3 and Table 4; or

c) for T5 classification, the surface temperature of a component with a surface area smaller than 1 000 mm^2 (excluding lead wires) shall not exceed 150 °C.

Items a), b), and c) do not apply to small components that produce a surface temperature rise as a result of a catalytic or other chemical reaction. The tests of 26.5.3 may be applied, but the flammable mixtures used shall be those that produce the highest component temperature due to the chemical reaction considering both the equipment group and the temperature class of the intended application.

Table 3 – Assessment of temperature classification according to component size

Total surface area excluding lead wires	Equipment Group II With temperature class T4		Equipment Group I Dust excluded	
	Maximum surface temperature	Maximum power dissipation	Maximum surface temperature	Maximum power dissipation
	°C	W	°C	W
<20 mm^2	275		950	
≥20 mm^2 ≤ 1 000 mm^2	200, or	per Table 4		per Table 4
>1 000 mm^2		per Table 4		per Table 4

Table 4 – Assessment of temperature classification Component surface area ≥ 20 mm^2

Variation in maximum power dissipation with respect to temperature

Maximum local temperature*	°C	Equipment group	40	50	60	70	80
Maximum power dissipation	W	Group II	1,3	1,25	1,2	1,1	1,0
		Group I (dust excluded)	3,3	3,22	3,15	3,07	3,0

* The local temperature is the temperature of the air surrounding the component (but not the component surface temperature), taking into account the heat from the component and other nearby components, and where relevant, external sources of heating, under normal operating conditions.

For potentiometers, the surface to be considered shall be that of the resistance element and not the external surface of the component. The mounting arrangement and the heat-sinking and cooling effect of the overall potentiometer construction shall be taken into consideration during the test. Temperature shall be measured on the track with that current which flows under the test conditions required by the standard for the specific Type of Protection. If this results in a resistance value of less than 10 % of the track resistance value, the measurements shall be carried out at 10 % of the track resistance value.

5.3.4 Component temperature of smooth surfaces for Group I or Group II electrical equipment

For surface areas of not more than 10 000 mm^2, the surface temperature may exceed that for the temperature class marked on the Group II electrical equipment or the corresponding maximum surface temperature for Group I electrical equipment, if there is no risk of ignition from these surfaces, with a safety margin of:

- 50 K for Group II temperature classes T1, T2 and T3;
- 25 K for Group II temperature classes T4, T5 and T6;
- 25 K for Group I.

This safety margin shall be ensured by experience based on tests of similar components or by tests of the electrical equipment itself in representative explosive mixtures for the specific temperature class.

NOTE A smooth heated surface sometimes permits a higher surface temperature before causing auto-ignition of a surrounding atmosphere. During the tests, the safety margin shown is often provided by increasing the ambient temperature or by increasing the power dissipation of the component. For methane, the second option is more practical.

6 Requirements for all equipment

6.1 General

The requirements of this standard, together with one or more of the specific standards listed in Clause 1, are in addition to the applicable safety requirements of the relevant industrial standards.

NOTE 1 It is not a requirement of this standard that compliance with the relevant industrial standards be verified.

NOTE 2 If the Ex Equipment or Ex Component is intended to withstand particularly adverse service conditions (for example, rough handling, humidity effects, ambient temperature variations, effects of chemical agents, corrosion), these are typically specified to the manufacturer by the user. If certification is sought, it is not a requirement of this standard that the certification body confirm suitability for the adverse conditions. Special precautions are typically taken when vibration effects on terminals, fuse holders, lampholders and current-carrying connections in general may impair safety, unless they comply with specific standards. For additional information on the application of Ex Equipment in low temperature conditions below –20 °C, see IEC TS60079-43[1], Explosive atmospheres – Part 43: Equipment in adverse service conditions

NOTE 3 The instructions are often used to identify specific adverse conditions for which the equipment is suitable.

6.2 Mechanical strength of equipment

The equipment shall be subjected to the tests of 26.4. Guards relied upon to provide protection from impact shall be removable only by the use of a tool and shall remain in place for the required impact tests.

6.3 Opening times

Enclosures which can be opened more quickly than:

a) any incorporated capacitors, charged by a voltage of 200 V or more, to discharge to a value of residual energy of:
   - 0,2 mJ for electrical equipment of Group I or Group IIA,
   - 0,06 mJ for electrical equipment of Group IIB,
   - 0,02 mJ for electrical equipment of Group IIC, including equipment marked Group II only,
   - 0,2 mJ for electrical equipment of Group III,

   or double the above energy levels if the charging voltage is less than 200 V, or

b) the surface temperature of enclosed hot components reduces to below the assigned maximum surface temperature of the electrical equipment:

   shall be marked with one of the following warning markings:
   - an enclosure opening delay marking as specified in item a) of 29.13; or
   - an enclosure opening marking as specified in item b) of 29.13.

[1] In preparation

6.4 Circulating currents in enclosures (e.g. of large electric machines)

Where necessary, precautions shall be taken to guard against any effect due to the presence of circulating currents caused by stray magnetic fields, and against the arcs or sparks that may occur as a result of interrupting such currents, or against excessive temperatures caused by such currents.

NOTE 1 Stray magnetic fields can result in significant currents flowing both within and between bolted sections of multi-section enclosures often employed for large rotating electric machines. This is most likely to occur during the starting of motors. It is important to avoid sparking from intermittent interruption of these currents.

NOTE 2 Although primarily a concern with large rotating electric machines, the same situation can occur in other equipment with large stray magnetic fields interacting with bolted sections of multi-section enclosures.

NOTE 3 Examples of precautions that can be taken include:

– the provision of equipotential bonding; or

– the provision of an appropriate configuration of fasteners.

Where equipotential bonding conductors are employed, they shall be adequately rated for the anticipated currents and they shall be arranged to ensure reliable current transfer without the risk of sparking under adverse operating conditions, such as vibration or corrosion. The bonds shall be protected against corrosion and loosening in accordance with 15.5 and 15.6. Particular care shall be taken with bare flexible conductors in close proximity to the bonded parts.

Bonding conductors are not required where insulation ensures that circulating currents cannot flow between parts. The insulation of such parts shall be capable of withstanding a voltage of 100 V RMS for 1 min. However, provision shall be made for adequate earthing of isolated exposed conductive parts.

6.5 Gasket retention

Where the degree of protection provided by the enclosure depends on a gasketed joint which is intended to be opened during installation or in normal operation, gaskets shall be attached or secured to one of the mating faces to prevent loss, damage or incorrect assembly. The gasket material shall not itself adhere to the other joint face. When the joint is opened and re-closed prior to the tests for degree of protection by enclosure, it shall be verified that the gasket material remains attached or secured, and has not adhered to the other joint face. (See 26.4.1.2).

If an adhesive is used to secure the gasket, the adhesive shall comply with the requirements for cements given in 7.1.2.4 and used within its COT.

6.6 Electromagnetic and ultrasonic energy radiating equipment

6.6.1 General

The energy levels shall not exceed the values given in 6.6.2 or 6.6.3, as applicable.

NOTE Additional information on the application of higher power radiating sources can be found, for Group I and Group II, in CLC/TR50427. The results of the TR are based on far field conditions.

6.6.2 Radio frequency sources

The threshold power of radio frequency (9 kHz to 60 GHz) for continuous transmissions and for pulsed transmissions whose pulse durations exceed the thermal initiation time shall not exceed the values shown in Table 5. Programmable or software control intended for setting by the user shall not be permitted.

Table 5 – Threshold power

Equipment for	Maximum threshold power W	Maximum thermal initiation time µs
Group I	6	200
Group IIA	6	100
Group IIB	3,5	80
Group IIC	2	20
Group III	6	200

For pulsed radar and other transmissions where the pulses are short compared with the thermal initiation time, the threshold energy values Z_{th} shall not exceed those given in Table 6.

Table 6 – Threshold energy

Equipment for	Maximum threshold energy Z_{th} µJ
Group I	1 500
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1 500

NOTE 1 In Table 5 and Table 6, the same values are applied for Ma, Mb, Ga, Gb, Gc, Da, Db, or Dc equipment due to the large safety factors involved.

NOTE 2 In Table 5 and Table 6, the values for Group III are adopted from Group I and not based on experimental results.

NOTE 3 In Table 5 and Table 6; the values apply in normal operation, provided that the user of the equipment does not have access to adjust the equipment to give higher values. It is not necessary to consider possible increases in power caused by faults, due to the large safety margins involved and the strong likelihood that RF amplifiers will rapidly fail if a fault occurs that significantly increases the output power.

6.6.3 Ultrasonic sources

The output parameters for single ultrasonic sources for equipment of EPL Ma, Mb, Ga, Gb, Gc, Da, Db or Dc shall not exceed the following values:

For gases and dusts:

– 10 MHz;
– for continuous sources – Sound Pressure Level (SPL) 170 dB (ref 20 µPa);
– for pulse sources (averaged over a 1s interval) – Average SPL of 170 dB (ref 20 µPa).

NOTE An SPL of 170 db (at 20 µPa as reference pressure level) represents a sound intensity of 10 W/cm^2, a significant relaxation from the former limit of 0,1 W/cm^2.

For liquids:

– 10 MHz;
– for continuous sources – Power density 40 W/cm^2;
– for pulse sources (averaged over a 1s interval) – Average power density 40 W/cm^2.

for $D > \lambda$, use $\frac{P}{\lambda^2}$ to calculate the power density,

for $D \leq \lambda$, use $\frac{P}{D^2}$ to calculate the power density.

Where

P = acoustic power or electrical input power

D = diameter of emitting surface (or the minor dimension if the emitting surface is rectangular)

λ = wavelength in the liquid

Where multiple ultrasonic sources additively overlay, the sum of the intensities shall also meet the thresholds.

6.6.4 Lasers, luminaires, and other non-divergent continuous wave optical sources

The requirements for lasers, luminaires, and other non-divergent continuous wave optical sources such as LED luminaires, torches, and optical fibre transmitters / receivers are contained in IEC 60079-28.

7 Non-metallic enclosures and non-metallic parts of enclosures

7.1 General

7.1.1 Applicability

The requirements given in this clause and in 26.7 shall apply to non-metallic enclosures and non-metallic parts of enclosures, on which the Type of Protection depends.

NOTE 1 Some examples of non-metallic parts of enclosures upon which the Type of Protection depends include cover sealing rings of an “e” or “t” enclosure, filling compounds of a “d” or “e” cable gland, sealing rings of cable glands, seals of switch actuators for an “e” enclosure, etc.

NOTE 2 Some of the subparts of this standard make the “non-metallic parts of enclosures” requirements given in this clause applicable to parts, which are not enclosures, but on which the Type of Protection depends, e.g. “d” bushings, “e” terminals.

7.1.2 Specification of materials

7.1.2.1 General

The documents according to Clause 24 shall specify the material of the enclosure or part of the enclosure.

7.1.2.2 Plastic materials

The specification for plastic materials shall include the following:

a) the name or registered trademark of the resin manufacturer or compounder;

b) the identification of the material, including its type designation and colour;

c) the possible surface treatments, such as varnishes, etc.;

d) 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 (either RTI – mechanical

strength or RTI – mechanical impact) may be determined in accordance with ANSI/UL 746B.

e) when applicable, data supporting compliance with 7.3 (resistance to ultraviolet light).

The source of the data for these characteristics shall be identified.

NOTE 1 It is not a requirement of this standard that conformity to the specification of the plastic material be verified.

NOTE 2 When selecting plastic materials, some manufacturers have noted that variations in type and percentage of fillers, flame retardants, ultra-violet light stabilizers, and the like can have a significant effect on the properties of the plastic material.

NOTE 3 Guidance on the traceability of materials can be found in ISO/IEC 80079-34. Manufacturers intending to use a “fingerprinting” method such as an infrared scan or oxygen index for traceability of plastics will need to be aware of that at the time of type testing so that baseline information can be obtained.

7.1.2.3 Elastomers

The specification for elastomers shall include the following:

a) the name or registered trademark of the resin manufacturer or compounder;

b) the identification of the material, including its type designation and colour;

c) the possible surface treatments, such as varnishes, etc.;

d) the continuous operating temperature (COT);

e) when applicable, data supporting compliance with 7.3 (resistance to ultraviolet light).

The source of the data for these characteristics shall be identified.

NOTE 1 It is not a requirement of this standard that conformity to the manufacturer’s specification of the elastomer be verified.

NOTE 2 When selecting elastomers, some manufacturers have noted that variations in type and percentage of fillers, flame retardants, ultra-violet light stabilizers, and the like can have a significant effect on the properties of the elastomer.

NOTE 3 Guidance on the traceability of materials can be found in ISO/IEC 80079-34. Manufacturers intending to use a “fingerprinting” method such as an infrared scan or oxygen index for traceability of elastomers will need to be aware of that at the time of type testing so that baseline information can be obtained.

7.1.2.4 Materials used for cementing

The specification for cements shall include the following:

a) the name or registered trademark of the cement manufacturer;

b) the identification of the material, including its type designation;

c) the continuous operating temperature (COT);

The source of the data for these characteristics shall be identified.

NOTE It is not a requirement of this standard that conformity to the manufacturer’s specification of the cement be verified.

7.2 Thermal endurance

7.2.1 Tests for thermal endurance

The tests for endurance to heat and to cold shall be conducted in accordance with 26.8 and 26.9. See also Order of tests, 26.4.1.

7.2.2 Material selection

The plastic materials shall have a temperature index “TI” or “either RTI – mechanical strength or RTI – mechanical impact” (according to 7.1.2) of at least 20 K (or 10 K for EPL Gc and Dc) greater than the maximum service temperature of the enclosure or the part of the enclosure (see 26.5.1).

The elastomers and materials used for cementing shall have a continuous operating temperature (COT) that includes a minimum temperature that is below, or equal to, the minimum service temperature and a maximum temperature that is at least 20 K (or 10 K for EPL Gc and Dc) above the maximum service temperature.

NOTE Equipment may have different service temperatures on different parts of the equipment. Selection and testing of individual materials is normally based on the specific service temperature of that part, but it is often based on the maximum (or minimum) service temperature of the complete equipment to simplify the testing program.

7.2.3 Alternative qualification of elastomeric sealing O-rings

Elastomeric sealing O-rings are normally qualified as a part of the complete equipment enclosure when the ingress protection of the enclosure (IP) is required by the Type of Protection. Alternatively, a metal enclosure incorporating elastomeric sealing O-rings, according to ISO 3601-1, used in defined mounting conditions according to ISO 3601-2, is permitted to be evaluated using a test fixture instead of testing the O-ring assembled in the complete equipment enclosure. The test fixture shall replicate the dimensions of the complete equipment enclosure O-ring mounting. The tests shall be conducted according 26.16**.** The O-ring is then mounted in the complete equipment enclosure and subjected to the required IP tests of 26.4.5.

NOTE The compression set value determined after the tests of 26.16 is necessary for subsequent comparison to O-rings of alternative materials for the same application.

For the qualification of additional O-ring materials, the IP tests are not required if, subsequent to the tests of 26.16, the compression set of the alternative O-ring is less than or equal to that of the originally tested O-ring.

7.3 Resistance to ultraviolet light

The resistance to ultraviolet (UV) light of the enclosures, or parts of enclosures, of non-metallic materials shall be satisfactory (see 26.10). Materials meeting the ultraviolet light exposure requirements (f1) in ANSI/UL 746C are considered satisfactory.

Where not otherwise protected from exposure to UV light, a test of resistance of the material to ultraviolet light shall be made if the enclosure or parts of the enclosure, upon which the Type of Protection depends, are made of non-metallic materials. For Group I equipment, the test applies only to luminaires.

NOTE 1 Internal parts of enclosures, not directly exposed to UV light, do not generally suffer a deleterious effect.

If the equipment is protected from UV light (for example, daylight or light from luminaires) when installed, and, in consequence, the test is not carried out, the equipment shall be marked by the symbol “X” to indicate this specific condition of use according to item e) of 29.3.

Gaskets and seals, constructed such that only an outer edge is potentially exposed to light, are not subject to the resistance to ultraviolet light requirements.

NOTE 2 It is generally acknowledged that glass and ceramic materials are not adversely affected by the resistance to UV light test, and testing may not be necessary.

NOTE 3 The tests for resistance to UV light are conducted on special test bars and not on the enclosure. Therefore, the special test bars are not required to be subjected to the tests of enclosures (26.4) prior to the tests for resistance to UV light.

7.4 Electrostatic charges on external non-metallic materials

7.4.1 Applicability

The requirements of 7.4 only apply to external non-metallic materials of equipment.

The requirements of 7.4 also apply to non-metallic parts which are applied to the external surface of an enclosure.

NOTE 1 Non-metallic paints, films, foils, and plates are typically attached to external surfaces of enclosures to provide additional environmental protection. Their ability to store an electrostatic charge is addressed by this clause.

NOTE 2 It is generally acknowledged that glass and ceramic surfaces are not susceptible to storing an electrostatic charge.

NOTE 3 Additional guidance on the risk of ignition from electrostatic discharge can be found in IEC TS 60079-32-1.

7.4.2 Avoidance of a build-up of electrostatic charge for Group I or Group II

Equipment is intended to be designed so that under normal conditions of use, danger of ignition due to electrostatic charges on external surfaces of enclosures is avoided. This shall be satisfied by employing one or more of the following techniques:

NOTE 1 It is often practical to employ different mitigation techniques on different parts of the equipment.

a) by selection of the material so that surface resistance shall meet at least one of the criteria given below when measured in accordance with 26.13:
   - ≤ 1 GΩ measured at (50 ± 5) % relative humidity;
   - ≤ 100 GΩ measured at (30 ± 5) % relative humidity.

b) by limitation of the surface area of non-metallic parts of enclosures as shown in Table 7.

   The surface area is defined as follows:

   - for sheet materials, the area shall be the exposed (chargeable) area;
   - for curved objects, the area shall be the projection of the object giving the maximum area;
   - for individual non-metallic parts, the area shall be evaluated independently if they are separated by conductive earthed frames.

   The permitted values of the surface area can be increased by a factor of four if this surface area of non-metallic material is surrounded by and in contact with a conductive earthed surface.

   The permitted values of the surface area can be increased by a factor of two if this surface area is, at the longest opposite sides, in contact with a conductive earthed surface.

   Alternatively, for long parts with non-metallic surfaces, such as tubes, bars, or ropes, the surface area need not be considered, but the diameters or widths shall not exceed the values shown in Table 8. Cables for connection of external circuits are not considered to fall under this requirement. See 16.7.

c) by limitation of the thickness of a non-metallic layer bonded to conductive or dissipative surfaces, which is connected to earth with a connection resistance of less than 1 GΩ. For the purposes of this standard, dissipative surfaces are those complying with the requirements of 7.4.2 a). The thickness of the non-metallic layer shall not exceed the values shown in Table 9 or the breakdown voltage shall be ≤4 kV DC (measured across the thickness of the insulating material according to the method described in IEC 60243-1 with the additional requirements of IEC 60243-2 for DC testing);

   NOTE 2 A painted enclosure complying with 7.4.2 c) and Table 9 only will not comply with 7.4.3 c).

d) by provision of a conductive or dissipative coating. Non-metallic surfaces may be covered with a bonded durable conductive or dissipative coating. The resistance between coating and either the point of bond (in the case of equipment for fixed installations) or the farthest point of potential contact with the enclosure (in the case of portable equipment) shall not exceed 1 GΩ. The resistance shall be measured in accordance with 26.13 but using a 100 mm^2 electrode at the worst case position of the surface and either the bond or the farthest point of potential contact. The equipment shall be marked “X” in accordance with item e) of 29.3 and the documentation shall provide guidance on the use of the bonding connection (for fixed equipment) and provide information to enable the user to decide on the durability of the coating material with respect to the environmental conditions;

NOTE 3 The environmental conditions that have an effect on the coating material may include influences from small particles in an air stream, solvent vapours, and the like.

e) for fixed installations where the installation is intended to minimize the risk from electrostatic discharge, by marking the equipment X” in accordance with item e) of 29.3. The instructions shall provide guidance for the user to minimize the risk from electrostatic discharge. Where practicable, the equipment shall also be marked with the electrostatic charge warning given in item g) of 29.13.

NOTE 4 Examples of possible guidance for the Specific Conditions of Use include:

– Control of environmental humidity to minimize the generation of static electricity.
– Protection from direct airflow causing a charge transfer.
– Touch with an insulating object.
– Means to continuously drain off electrostatic charges

f) for portable, mains powered, equipment, where the non-metallic materials are protected from charging or discharging by the provision of an earth-connected conductive or dissipative guard, the equipment shall be marked “X” in accordance with item e) of 29.3. The instructions shall provide guidance for the user to minimize the risk from electrostatic discharge. Where practicable, the equipment shall also be marked with the electrostatic charge warning given in item g) of 29.13.

g) by testing that the maximal transferred charge measured according to 26.17 is within the threshold limits of Table 10.

NOTE 5 In many industrial applications, including coal mining, it is highly likely that warning labels may become illegible through the deposition of dusts. If this is the case, it is possible that the act of cleaning the label can cause a static discharge.

NOTE 6 A minimum insulation resistance for electrical insulating materials is normally specified to avoid problems arising from touching exposed non-metallic parts that are in contact with live parts.

Table 7 – Limitation of surface areas

Maximum surface area mm^2				
Group I equipment	**Group II equipment**			
	Equipment Protection Level	**Group IIA**	**Group IIB**	**Group IIC**
10 000	EPL Ga	5 000	2 500	400
	EPL Gb	10 000	10 000	2 000
	EPL Gc	10 000	10 000	2 000

Table 8 – Maximum diameter or width

Maximum diameter or width mm				
Group I equipment	Group II equipment			
	Equipment Protection Level	Group IIA	Group IIB	Group IIC
30	EPL Ga	3	3	1
	EPL Gb	30	30	20
	EPL Gc	30	30	20

Table 9 – Limitation of thickness of non-metallic layer

Maximum thickness mm				
Group I equipment	Group II equipment			
	Equipment Protection Level	Group IIA	Group IIB	Group IIC
2	EPL Ga	2	2	0,2
	EPL Gb	2	2	0,2
	EPL Gc	2	2	0,2

NOTE 7 These thickness limitations do not apply to non-metallic layers that have a surface resistance of less than 1 GΩ or 100 GΩ, as applicable. See 7.4.2 a).

NOTE 8 One of the main reasons for the thickness limitation is that the maximum thickness of the non-metallic layer is intended to bind the static charge at the surface. By this means the static charge is not able to build incendive discharges.

Table 10 – Maximum acceptable transferred charge

Maximum acceptable transferred charge nC				
Group I equipment	Group II equipment			
	Equipment Protection Level	Group IIA	Group IIB	Group IIC
60	EPL Ga	60	25	10
	EPL Gb	60	25	10
	EPL Gc	60	25	10
NOTE The limits ensure that incendive discharges do not occur.				

7.4.3 Avoidance of a build-up of electrostatic charge for Group III

External surface of enclosures of plastic material and painted/coated metal enclosures are intended to be designed so that under normal conditions of use, danger of ignition due to propagating brush discharges is avoided.

Enclosures of plastic material cannot be charged to such a critical charge density that propagating brush discharges can be generated. However, no extended flat conductive surfaces shall be installed inside the enclosure within a distance of 8 mm to the outer surface.

An internal printed circuit board may be considered to be an extended flat conductive surface, though this need not be applied in small portable or personal equipment unless the equipment is likely to be subjected to a prolific charge generating mechanism (such as might occur in pneumatic transfer of powders or charge spraying in a powder coating process). Charging through normal handling of portable or personal equipment is not considered to lead to a prolific charge generating mechanism and therefore would not lead to a situation where a propagating brush discharge might occur.

NOTE 1 A single flat conductive surface not exceeding 500 mm^2 is not considered to be an extended flat surface. This allows for the standoffs or brackets used for the mounting of conductive flat plates inside of an enclosure.

NOTE 2 Discharges from insulating surfaces, not backed with conductive material, are unable to ignite an explosive dust atmosphere.

NOTE 3 Charging mechanisms such as manual rubbing are not an ignition risk for explosive dust atmospheres. However, charging mechanisms such as fast moving particles along a surface, pneumatic transfer of powders, and charge spraying in an electrostatic coating process; generally lead to a risk of ignitable discharges from insulating surfaces exceeding 500 mm^2 backed with conductive material connected to earth with a resistance 1 MΩ or less.

If plastic material or elastomer with a surface area exceeding 500 mm^2 is employed as a covering on a conductive material, one or more of the following mitigating techniques shall be employed:

NOTE 4 It is often practical to employ different mitigation techniques on different parts of the equipment.

a) by selection of the material so that surface resistance shall meet at least one of the criteria given below when measured in accordance with 26.13:
   - ≤ 1 GΩ measured at (50 ± 5) % relative humidity;
   - ≤ 100 GΩ measured at (30 ± 5) % relative humidity.

b) by selection of a material with a breakdown voltage ≤ 4 kV DC (measured across the thickness of the insulating material according to the method described in IEC 60243-1 with the additional requirements of IEC 60243-2 for DC testing);

c) by controlling the thickness of the non-metallic material to be ≥ 8 mm.

NOTE 5 A painted enclosure complying with 7.4.2 c) and Table 9 only will not comply with 7.4.3 c). When applied for both explosive gas atmospheres and explosive dust atmospheres, application of 7.4.2 a) and 7.4.3 a); or 7.4.2 c) and 7.4.3 b) are often used.

NOTE 6 External insulation of 8 mm and greater on metal parts such as measurement probes or similar components make propagating brush discharges unlikely to occur. When evaluating the minimum thickness of the insulation to be used or specified it is common to allow for any expected wear under normal usage.

d) by marking the equipment “X” in accordance with item e) of 29.3. This is only applicable to equipment intended for fixed installations where the installation is intended to minimize the risk from electrostatic discharge. The instructions shall provide guidance for the user to minimize the risk from electrostatic discharge.

7.5 Attached external conductive parts

External conductive parts, such as labels, which are attached to the non-metallic enclosure or are part of the non-metallic enclosure, with a resistance to earth of more than 1 GΩ measured at (500 ± 25) Vdc, could be susceptible to electrostatic charges that could become a source of ignition. The capacitance of such parts shall be determined in accordance with the test method in 26.14.

For equipment:

- Other than portable or personal; and
- where the measured capacitance of any conductive part exceeds the value shown in Table 11,

the equipment shall be marked “X” in accordance with item e) of 29.3 and the specific condition of use shall specify the value of capacitance determined to allow the user to

determine suitability in the specific application. External conductive parts that are situated such that discharges to approaching earthed objects are not expected need not be tested.

Table 11 – Maximum capacitance of unearthed conductive parts

Maximum capacitance pF				
Group I or Group III equipment	Group II equipment			
	Equipment Protection Level	Group IIA	Group IIB	Group IIC
10	EPL Ga	3	3	3
	EPL Gb	10	10	3
	EPL Gc	10	10	3

NOTE 1 It is generally accepted that an unearthed metal fastener such as a cover screw will present a capacitance of not more than 3 pF.

NOTE 2 For Group III equipment intended for use in ducts or pipes subject to the presence of fast moving dust, a lower limiting value for capacitance is under consideration.

8 Metallic enclosures and metallic parts of enclosures

8.1 Material composition

The documents according to Clause 24 shall specify the material of the enclosure or part of the enclosure.

NOTE 1 It is not a requirement of this standard that the chemical composition of material be verified by test.

NOTE 2 Paint or coatings applied to metallic enclosures are non-metallic parts of an enclosure and the requirements of 7.4 apply.

NOTE 3 Zinc and zinc alloys of 80% zinc or greater tend to deteriorate rapidly (particularly tensile strength), especially in warm, moist air. Zinc is also considered more reactive than most other metals. Some of the Types of Protection do not permit the use of zinc for enclosures.

8.2 Group I

Materials used in the construction of enclosures of Group I equipment of EPL Ma or Mb shall not contain, by mass, more than

- 15 % in total of aluminium, magnesium, titanium and zirconium, with no more than 7,5 % in total of magnesium, titanium and zirconium.

The above requirement need not apply to Group I portable measuring equipment, but this equipment shall then be marked “X” in accordance with item e) of 29.3 and the specific condition of use shall indicate the special precautions to be applied during storage, transportation and use.

8.3 Group II

Materials used in the construction of enclosures of Group II equipment for the identified Equipment Protection Levels shall not contain, by mass, more than:

- for EPL Ga

  10 % in total of aluminium, magnesium, titanium and zirconium, with no more than 7,5 % in total of magnesium, titanium and zirconium;

- for EPL Gb

7,5 % in total of magnesium, titanium and zirconium;

- for EPL Gc

  no requirements except for fan impellors, fan hoods and ventilating screens, which shall comply with the requirements for EPL Gb.

When the material limits are exceeded for equipment of EPL Ga or Gb, the equipment shall be marked with an "X" in accordance with item e) of 29.3 and the specific conditions of use shall contain sufficient information to enable the user to determine the suitability of the equipment for the particular application, for example, to avoid an ignition hazard due to impact or friction.

8.4 Group III

Materials used in the construction of enclosures of Group III equipment for the identified Equipment Protection Levels shall not contain, by mass, more than:

- for EPL Da

  7,5 % in total of magnesium, titanium and zirconium;

- for EPL Db

  7,5 % in total of magnesium, titanium and zirconium;

- for EPL Dc

  no requirements except for fan impellors, fan hoods and ventilating screens, which shall comply with the requirements for EPL Db.

When the material limits are exceeded for equipment of EPL Da or Db, the equipment shall be marked with an "X" in accordance with item e) of 29.3 and the specific conditions of use shall contain sufficient information to enable the user to determine the suitability of the equipment for the particular application, for example, to avoid an ignition hazard due to impact or friction.

8.5 Copper Alloys

Where intended for use in atmospheres containing acetylene, enclosures of equipment and enclosures of Ex components for external mounting, if constructed of copper or copper alloys:

- shall be coated with tin, nickel, or by other coatings; or
- shall have the maximum copper content of the alloy limited to 65 %.

Cable glands as defined in Annex A, Blanking Elements, Thread Adapters, and bushings are not considered an enclosure surface requiring coating or copper content restriction.

NOTE The restriction of the use of copper in acetylene atmospheres is due to the potential formation of acetylides on external surfaces that can be ignited by friction or impact.

9 Fasteners

9.1 General

Parts necessary to achieve a specific Type of Protection or used to prevent access to uninsulated live parts shall be capable of being released or removed only with the aid of a tool such as a key, screwdriver, or wrench.

Fastening screws for enclosures of materials containing aluminium, magnesium, titanium or zirconium may be made of aluminium, magnesium, titanium, zirconium, or non-metallic material if the material of the fastener is compatible with that of the enclosure.

Threaded holes for fasteners which secure covers intended to be opened in service for adjustment, inspection and other operational reasons shall only be tapped into the material when the thread form is compatible with the material of the enclosure.

9.2 Special fasteners

When any of the standards for a specific Type of Protection requires a special fastener, this shall conform to the following:

– the thread shall be a metric thread of coarse pitch in accordance with ISO 262, with a tolerance fit of 6g/6H in accordance with ISO 965-1 and ISO 965-3;

– the head of the screw or nut shall be in accordance with ISO 4014, ISO 4017, ISO 4032, ISO 4762, ISO 7380, or ISO 14583 and, in the case of hexagon socket set screws, ISO 4026, ISO 4027, ISO 4028 or ISO 4029; Other heads of a screw or nut are permitted if the equipment is marked “X” in accordance with item e) of 29.3 and the specific condition of use shall fully specify the fasteners and indicate that the fasteners shall only be replaced with identical ones;

– the holes in the equipment shall comply with the requirements of 9.3.

9.3 Holes for special fasteners

9.3.1 Thread engagement

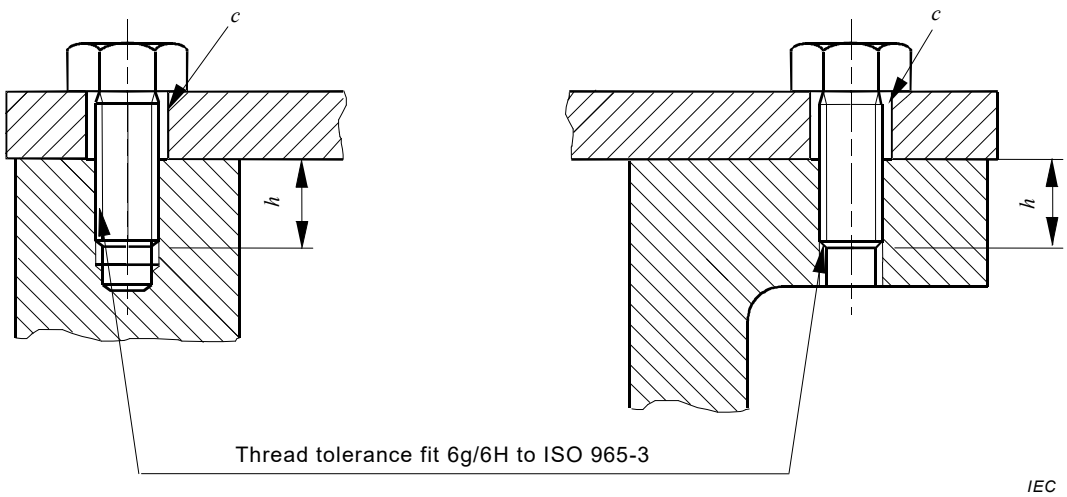
Holes for special fasteners, as specified in 9.2, shall be threaded for a distance to accept a thread engagement, h, at least equal to the major diameter of the thread of the fastener (see Figure 4 and Figure 5).

9.3.2 Tolerance and clearance

The internal thread shall have a tolerance class of 6H in accordance with ISO 965-1 and ISO 965-3, and either

a) the hole under the head of the associated fastener shall allow a clearance not greater than that specified for the “medium series: H13” per ISO 273 (see Figure 4); or

b) the hole under the head (or nut) of an associated reduced shank fastener shall be threaded to enable the fastener to be retained. The dimensions of the threaded hole shall be such that the surrounding surface in contact with the head of such a fastener shall be at least equal to that of a fastener without a reduced shank in a clearance hole (see Figure 5).

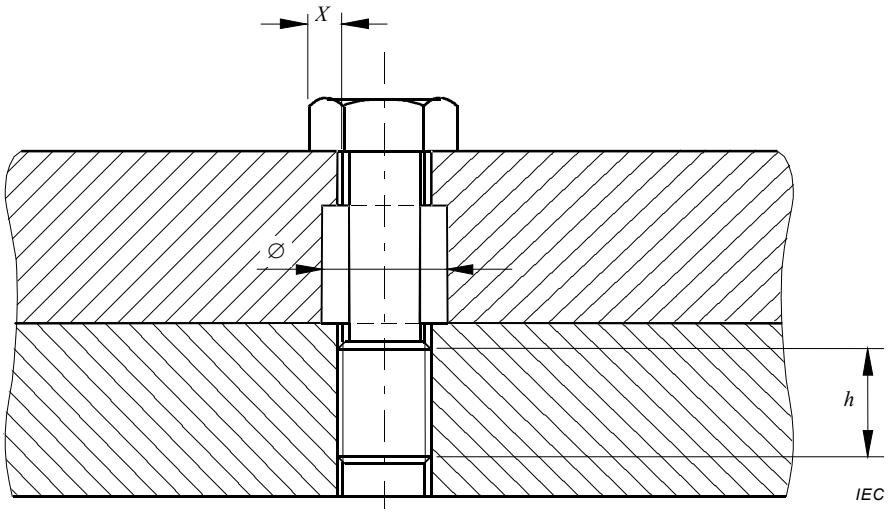


Key

h thread engagement ≥ major diameter of the thread of the fastener

c ≤ maximum clearance permitted for the “medium series: H13” per ISO 273

Figure 4 – Tolerances and clearance for threaded fasteners



Key

∅ standard clearance hole appropriate to the thread form

h thread engagement ≥ major diameter of the thread of the fastener

X contact dimension of a reduced shank fastener

X ≥ the contact dimension of a standard head of a standard fastener (without reduced shank) threaded throughout its length with the size of thread used

Figure 5 – Contact surface under head of fastener with a reduced shank

9.4 Hexagon socket set screws

Hexagon socket set screws, used to secure threaded covers, shall not protrude from the threaded hole after tightening.

10 Interlocking devices

Where an interlocking device is used to maintain a specific Type of Protection, it shall be so constructed that its effectiveness cannot easily be defeated.

NOTE The intent is that the interlock be designed such that it cannot be easily defeated by common tools such as a screwdriver, pliers, or a similar tool.

11 Bushings

Bushings used as field wiring connection facilities and which may be subjected to a torque during connection or disconnection, shall be mounted in such a way that all parts are secured against turning.

The relevant torque test is specified in 26.6.

12 (Reserved for future use)

13 Ex Components

13.1 General

Ex Components shall comply with the requirements given in Annex B. Examples of Ex Components include:

a) an empty enclosure; or

b) components or assemblies of components for use with equipment which complies with the requirements of one or more of the types of protection listed in Clause 1.

13.2 Mounting

Ex Components may be mounted:

a) completely within an equipment enclosure (for example, a Type of Protection "e" terminal, ammeter, heater or indicator; a Type of Protection "d" switch component or thermostat, a Type of Protection “m” switch component or thermostat, a Type of Protection "i" supply); or

b) completely external to the equipment enclosure (for example, a Type of Protection "e" earth terminal, a Type of Protection "i" sensor); or

c) partly within and partly external to the equipment enclosure (for example, a Type of Protection "d" push button switch, a Type of Protection “t” push button switch, a limit switch or indicating lamp, a Type of Protection "e" ammeter, a Type of Protection "i" indicator).

13.3 Internal mounting

Where the Ex Component is mounted completely within the enclosure, the only parts that shall be tested or assessed are those parts which have not been tested and/or assessed as a separate component (for example, test or assessment of surface temperature, creepage distance and clearance from the component to surrounding conducting parts).

13.4 External mounting

Where the Ex Component is mounted external to the enclosure or partly within and partly external to the enclosure, the interface between the Ex Component and the enclosure shall be tested or assessed for compliance with the relevant Type of Protection and the enclosure tests as specified in 26.4.

13.5 Ex Component certificate

As Ex Components are not intended to be used alone and require additional consideration when incorporated into equipment or systems, they do not have “Specific Conditions of Use” along with the associated “X” suffix for the certificate number. Where this standard or one of its sub-parts specify “Specific Conditions of Use” and the associated “X” suffix for the certificate number, a “Schedule of Limitations” for the Ex Component certificate and the associated “U” suffix for the Ex Component certificate number shall be substituted for an Ex Component. Information necessary to correctly apply the Ex Component shall be included in the Schedule of Limitations on the Certificate. See also 28.2 and Annex B.

NOTE 1 The Schedule of Limitations includes the temperature range for the Ex Component. In some cases, ranges at multiple points are defined to allow maximum flexibility in the application of the Ex Component.

NOTE 2 In accordance with Annex B, Ex Components are not assigned a temperature class.

14 Connection facilities

14.1 General

Electrical equipment intended for connection to external circuits shall include connection facilities, with the exception of electrical equipment that is manufactured with a cable permanently connected to it.

14.2 Type of protection

Connection facilities shall comply with one of the specific Types of Protection listed in Clause 1.

14.3 Creepage and clearance

Connection facilities shall be so designed that after proper connection of the conductors, the creepage distances and the clearances comply with the requirements, if any, of the specific Type of Protection concerned.

15 Connection facilities for earthing or bonding conductors

15.1 Equipment requiring earthing or bonding

15.1.1 Internal earthing

A connection facility for the connection of an earthing conductor shall be provided inside the electrical equipment adjacent to the other connection facilities. See also 15.2 for equipment not requiring internal earthing.

15.1.2 External bonding

An additional external connection facility for an equipotential bonding conductor shall be provided for electrical equipment with a metallic enclosure, except for electrical equipment which is designed to be:

a) moved when energized and is supplied by a cable incorporating an earthing or equipotential bonding conductor; or

b) installed only with wiring systems not requiring an external earth connection, for example, metallic conduit or armoured cable.

The manufacturer shall provide details on any earthing or equipotential bonding required for the installation under conditions a) or b) above in the instructions provided in accordance with Clause 30.

The additional external connection facility shall be electrically in contact with the connection facility required in 15.1.1.

NOTE The expression "electrically in contact" does not necessarily involve the use of a conductor.

15.2 Equipment not requiring earthing

Where there is no requirement for earthing, for example, in some types of electrical equipment having double or reinforced insulation, or for which supplementary earthing is not necessary, an internal earthing facility in accordance with 15.1.1 need not be provided.

NOTE Some electrical equipment, such as double insulated equipment, while not presenting a risk of electrical shock, is often bonded to reduce the risk of ignition due to electrostatic hazards.

15.3 Size of protective earthing conductor connection

Protective earthing (PE) conductor connection facilities shall allow for the effective connection of at least one conductor with a cross-sectional area given in Table 12. Protective earthing (PE) conductor connection facilities for electric machines shall be according to IEC 60034-1.

Table 12 – Minimum cross-sectional area of PE conductors

Cross-sectional area of phase conductors, S mm^2	Minimum cross-sectional area of the corresponding PE conductor, S_p mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	0,5 S

15.4 Size of equipotential bonding conductor connection

Equipotential (EP) bonding connection facilities on the outside of equipment shall provide effective connection of a conductor with a cross-sectional area of at least 4 mm^2. When this connection facility is also intended to serve as the PE connection, the requirements of Table 12 apply, but with a cross-sectional area of at least 4 mm^2.

15.5 Protection against corrosion

Connection facilities shall be effectively protected against corrosion. Special precautions shall be taken if one of the parts in contact consists of a material containing aluminium, magnesium, titanium, or zirconium, for example, by using an intermediate part made of steel when making a connection to a material containing aluminium, magnesium, titanium, or zirconium.

15.6 Secureness of electrical connections

Connection facilities shall be designed so that the electrical conductors cannot be readily loosened or twisted. Except as permitted in 15.7, contact pressure on the electrical connections shall be maintained and not be affected by dimensional changes of insulating materials in service, due to factors such as temperature or humidity.

NOTE 1 Lockwashers are often employed to provide a means of avoiding loosening of the connection.

NOTE 2 Means often employed to avoid twisting of the electrical conductors include the use of a fixed connection bar with a U-shaped clamp, anti-rotation recesses or ribs on the enclosure, and the like.

15.7 Internal earth continuity plate

For non-metallic walled enclosures provided with an internal earth continuity plate, the test of 26.12 shall be applied.

NOTE An internal earth continuity plate is often fitted, for example, to allow for use of metallic cable glands without the use of separate individual earthing tags.

16 Entries into enclosures

16.1 General

Entry into the equipment shall be either by a plain or threaded hole located in:

- the wall of the enclosure, or
- an adaptor plate designed to be fitted in or on the walls of the enclosure.

NOTE Further information on the installation of conduit or associated fittings into threaded or plain holes can be found in IEC 60079-14.

16.2 Identification of entries

The manufacturer shall specify, in the documents submitted according to Clause 24, the entries, their position or area / location on the equipment and the number permitted. The

thread form (for example, metric or NPT) of threaded entries shall be marked on the equipment or shall appear in the installation instructions (see Clause 30).

NOTE 1 It is not intended that individual entries be marked, unless required by the specific Type of Protection.

NOTE 2 Where a great variety of possible locations for entries is foreseen, information on the area for the entries, the size of entries and entry spacing are typically provided in the instructions.

16.3 Cable glands

Cable glands, when installed in accordance with the instructions required by Clause 30, shall not invalidate the specific characteristics of the Type of Protection of the electrical equipment on which they are mounted. This shall apply to the whole range of cables specified by the manufacturer of the cable glands as suitable for use with those glands. Cable glands may form an integral part of the equipment where one major element or part forms an inseparable part of the enclosure of the equipment. In such cases, the glands shall be tested with the equipment.

Non-threaded cable glands, for Group I, shall be:

- Ex Equipment Cable Glands;
- Ex Components; or
- included as part of the certificate for the complete equipment.

Non-threaded cable glands, for Group II or Group III, shall be:

- Ex Components; or
- included as part of the certificate for the complete equipment.

Threaded cable glands and cable transit devices, for Group I, Group II, or Group III, shall be:

- Ex Equipment Cable Glands;
- Ex Components; or
- included as part of the certificate for the complete equipment.

Cable glands and cable transit devices, whether integral or separate, shall meet the relevant requirements of Annex A.

NOTE All of the requirements for cable glands marked as Level of Protection “eb” are located in IEC 60079-0.

16.4 Blanking elements

Blanking elements, intended to close unused openings in the enclosure walls of electrical equipment, shall satisfy the requirements of the specific Type of Protection concerned. The blanking element shall only be removable with the aid of a tool.

Threaded blanking elements shall be Ex Equipment Blanking Elements, Ex Components, or included as part of the certificate for the complete equipment.

Non-threaded blanking elements, for Group I, shall be Ex Equipment Blanking Elements, Ex Components, or included as part of the certificate for the complete equipment.

Non-threaded blanking elements, for Group II or Group III, shall be Ex Components or included as part of the certificate for the complete equipment.

16.5 Thread adapters

Thread adapters shall satisfy the requirements of the specific Type of Protection concerned.

Thread adapters shall be Ex Thread Adapters, Ex Components, or included as part of the certificate for the complete equipment.

16.6 Temperature at branching point and entry point

When the service temperature is higher than 70 °C at the entry point or 80 °C at the branching point of the conductors, information shall be marked on the equipment exterior to provide guidance to the user on the proper selection of cable and cable gland or conductors in conduit. See Figure 6 and Figure 7.

In cases where the information for the proper selection of cables, cable glands, and conductors in conduit is extensive, the marking need only be a reference to detailed information in the equipment instructions.

16.7 Electrostatic charges of cable sheaths

For the purposes of this standard, the sheaths of cables are not considered non-metallic enclosures or parts of enclosures as described by Clause 7 and need not be assessed against those requirements.

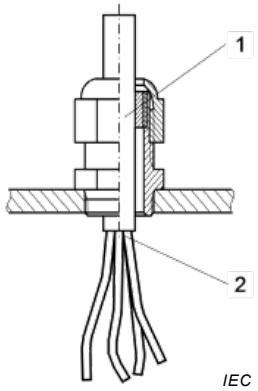
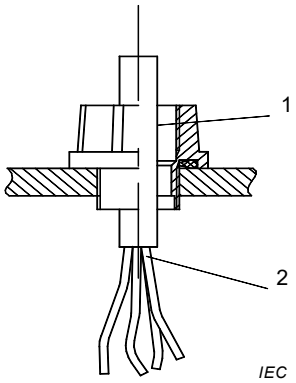


Figure 6 – Cable gland



Key

1 entry point (where the cable sealing, if any, occurs)

2 branching point

Figure 7 – Conduit entry

17 Supplementary requirements for electric machines

17.1 General

The requirements in this clause apply to rotating electric 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.

17.2 Ventilation

17.2.1 Ventilation openings

The degree of protection (IP) of ventilation openings shall be at least:

– IP20 on the air inlet side,

– IP10 on the air outlet side,

according to IEC 60034-5.

For vertical rotating electric machines and vertical rotating fans, foreign objects shall be prevented from falling into the ventilation openings. For Group I rotating machines, the degree of protection IP10 is adequate only when the openings are designed or arranged so that foreign objects with dimensions above 12,5 mm cannot be carried onto the moving parts of the machine either by falling vertically or by vibration.

For fans intended to be mounted in ventilation duct systems, the requirements for IP-protection and other requirements for parts providing the IP-protection (e.g. impact test, material requirements) can be fulfilled at the inlet and outlet of the duct. In such a case, the fan shall be marked “X” in accordance with item e) of 29.3 and the specific condition of use shall specify the criteria for the selection of the inlet and outlet guarding.

17.2.2 Materials for external fans

The external fan impellors, fan hoods, and ventilation screens manufactured from non-metallic materials shall comply with Clause 7. For Group II rotating machines, impellors of external fans having a peripheral speed of below 50 m/s, need not comply with the requirements of 7.4.

The external fan impellors, fan hoods, and ventilation screens manufactured from materials containing aluminium, magnesium, titanium, or zirconium, shall comply with Clause 8.

17.2.3 Cooling fans of rotating electric machines

NOTE The external cooling fans referred to in this subclause are the fans used to cool the rotating electric machine itself, not for the cooling of some other equipment.

17.2.3.1 Fans and fan hoods

External cooling fans of rotating electric machines, shall be enclosed by a fan hood, and shall meet the requirements of 17.2.3.2 and 17.2.3.3.

17.2.3.2 Construction and mounting of the ventilating systems

Fans, fan hoods and ventilation screens shall be constructed to meet the requirements of the resistance to impact test according to 26.4.2 and the acceptance criteria given in 26.4.4.

17.2.3.3 Clearances for the ventilating system

Taking into account design tolerances, the clearances in normal operation between the fan impellor and its fan hood, the ventilation screens and their fasteners, shall be at least one-hundredth of the maximum diameter of the fan impellor, except that the clearances need not exceed 5 mm and may be reduced to 1 mm where the opposing parts are manufactured so as to have controlled dimensional concentricity and dimensional stability (e.g. machined parts of cast metal). In no case shall the clearance be less than 1 mm.

17.2.4 Auxiliary motor cooling fans

Cooling fans that are not mounted on the shaft of the motor to be cooled, and which require a minimum back-pressure in order to not exceed the rating of the fan motor, shall either be tested as part of the motor to be cooled or shall be marked “X” in accordance with item e) of 29.3 and the specific condition of use shall specify the measures to be considered to not exceed the ratings. If limits for back-pressure are specified as such conditions, these limits shall be verified by testing according to 26.15.

17.2.5 Room ventilating fans

17.2.5.1 Applicability

The requirements given in 17.2.5 shall apply for ventilating fans ranging up to 5 kW, with the fan impellor directly mounted to the electrical motor shaft. Ventilating fans in EPL Ma, Ga, or Da are not permitted.

NOTE 1 These requirements apply for ventilating fans (e.g. room ventilators) with the same EPL inside and outside the fan enclosure, for use with the same zone inside and outside the enclosure. Where fan enclosures are intended to separate a hazardous area inside the enclosure from another hazardous area outside the enclosure, additional requirements need to be considered e.g. requirements for the tightness of the enclosure.

NOTE 2 This subclause addresses explosion protection requirements for ventilating fans intended to be used in hazardous areas, not functional requirements for ventilating fans.

NOTE 3 Ventilating fans in EPL Ma, Ga, and Da are not permitted as these applications would be considered to be transfer of flammable process media, and not a ventilation function transferring air.

17.2.5.2 General

The requirements given in 17.2.5 shall apply, together with any other applicable requirement of this standard. The ratings of the fan shall not exceed the ratings of the motor. Fans which require a minimum back-pressure in order to not exceed the rating of the motor, shall be marked “X” in accordance with item e) of 29.3 and the specific condition of use shall specify the measures to be considered to not exceed the ratings. If limits for back-pressure are specified as such conditions, these limits shall be verified by testing according to 26.15.

17.2.5.3 Fan and fan hoods

The rotating parts of the fan shall be enclosed by a fan hood which is not considered to be part of the enclosure of any electrical equipment used in the fan e.g. the electrical motor. The fan and fan hood shall meet the requirements of 17.2.5.4 and 17.2.5.5.

17.2.5.4 Construction and mounting

Parts of the fan which may cause contact between rotating parts and fixed parts (e.g. fan hoods and ventilation screens) shall meet the requirements of the resistance to impact test according to 26.4.2 and the acceptance criteria given in 26.4.4.

In order to avoid excessive temperatures at the shaft seals, material pairings used for the shaft and seal casing shall comply with 17.2.2 and the clearances between such parts shall comply with 17.2.5.5.

17.2.5.5 Clearances for rotating parts

Taking into account design tolerances, the clearances in normal operation between the fan impellor and the fan hood, the ventilation screens and their fasteners, shall be at least one-hundredth of the diameter of the fan impellor. However, the clearance shall not be less than 2,0 mm except that the requirement of 2,0 mm may be reduced to 1,0 mm where the opposing parts are manufactured so as to have controlled dimensional concentricity and dimensional stability (e.g. machined parts of cast metal). For fans with such controlled dimensional concentricity and dimensional stability, the clearances need not exceed 5,0 mm.

17.3 Bearings

Lubricants and seals used in bearings shall be suitable for the maximum service temperature of the bearings.

NOTE 1 Additional guidance is typically provided in the instructions to address installation and operation conditions that can have a direct effect on the rotating machine such as lubrication, bearings, shaft currents, vibration, and the like. See 30.3

NOTE 2 Shaft and bearing currents may be a primary source of ignition, and may also considerably influence the lifetime of the bearings. Practice has shown that the lifetime can be only few weeks and thus practically impossible to predict by traditional conditioning monitoring methods. Annex D and Annex H provide additional guidance on the analysis of shaft currents in the system, and system design to reduce the likelihood of unexpected bearing damage.

NOTE 3 At the present time, no suitable experimental test exists to demonstrate that a given type of bearing has a low risk of becoming an ignition source in service. Ball and roller bearing manufacturers do, however, quote a basic rated life corresponding to a probability of mechanical failure occurring during operation (e.g. failure by deformation of an element, or fatigue flaking or spalling occurring on one of its elements). This basic rating can be used to estimate the risk of bearing malfunction that might lead to the production of an incendive hot surface or sparks. The basic rated life of a ball/roller bearing is based on the amount of radial and axial loading that a ball/roller bearing can theoretically endure for one million revolutions. It is usually expressed as an “L” value in terms of foreseeable lifetime operating revolutions, or foreseeable lifetime hours of service. In an attempt to reduce the risk of malfunction in service to a minimum, it is paramount that the equipment manufacturer pays attention to good design, the ratio of the axial and radial loadings, construction, lubrication, cooling, and maintenance procedures. Regular examination during operation is one way to detect impending malfunction. If bearings act as an insulator, constructive measures are applied to effectively bond other parts of the equipment.

NOTE 4 The service life of bearings greatly depends on the service conditions and it is therefore not possible to reliably calculate their service life without knowledge of the service conditions to which they are being subjected.

18 Supplementary requirements for switchgear

18.1 Flammable dielectric

Switchgear shall not have contacts immersed in flammable dielectric.

18.2 Disconnectors

Where switchgear includes a disconnector, it shall disconnect all poles. The switchgear shall be designed so that either:

– the position of the disconnector contacts is visible, or

– their open position is reliably indicated (see IEC 60947-1).

If an interlock is provided for the cover or door of the switchgear, this interlock shall ensure that the cover or door can only be opened when the disconnector contacts are open.

If an interlock is not provided for the cover or door of the switchgear, a warning according to item d) of 29.13 shall be marked on the equipment.

For a “maintenance switch” in accordance with IEC 62626-1, the switch shall be provided with a padlocking system which padlocks the switch in the OFF position. The enclosure can only be opened with this switch in the ON position.

NOTE 1 An enclosure with an interlock, containing both a disconnector and a “maintenance switch” can only be opened when the disconnector is OFF and the “maintenance switch” is ON.

NOTE 2 A single switch serving as both a disconnector and a “maintenance” switch can only be marked with a warning according to item d) of 29.13, as it is not possible to simultaneously comply with the interlock requirements for a disconnector and the interlock requirements for a “maintenance switch”.

Disconnectors, which are not designed to be operated under the intended load, shall either

– be electrically or mechanically interlocked with a suitable load breaking device, or
– for Group II equipment only, be marked at a place near the actuator of the disconnector, with the operation under load marking given in item c) of 29.13.

18.3 Group I – Provisions for locking

For Group I switchgear, the operating mechanism of disconnectors shall be capable of being padlocked in the open position. Provision shall be made to enable short-circuit and earth-fault relays, if used, to latch out. If the switchgear has a local resetting device which is accessible from the outside of the enclosure, its access cover shall have a special fastener according to 9.2.

18.4 Doors and covers

Doors and covers giving access to the interior of enclosures containing remotely operated circuits with switching contacts which can be made or broken by non-manual influences (such as electrical, mechanical, magnetic, electromagnetic, electro-optical, pneumatic, hydraulic, acoustic or thermal) shall either:

a) be interlocked with a disconnector which prevents access to the interior, unless it has been operated to disconnect unprotected internal circuits; or
b) be marked with the enclosure opening marking of item d) of 29.13.

In the case of a) above, where it is intended that some internal parts shall remain energized after operation of the disconnector, in order to minimize the risk of explosion, those energized parts shall be protected by either:

1) one of the appropriate types of protection listed in Clause 1; or
2) protection as follows:
   – clearances and creepage distances between phases (poles) and to earth in accordance with the requirements of IEC 60079-7; and
   – internal supplementary enclosure(s) which contain(s) the energized parts and provide(s) a degree of protection of at least IP20, according to IEC 60529; and
   – marking on the internal supplementary enclosure as required by item h) of 29.13.

NOTE Equipment that can remain energized after the operation of the disconnector includes equipment supplied by cells and batteries internal to the equipment.

19 Reserved for future use

20 Supplementary requirements for external plugs, socket outlets and connectors for field wiring connection

20.1 General

These requirements for socket outlets shall also be applied to connectors.

Plugs and socket outlets shall be either:

a) 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 the plug and socket outlet are separated, or

b) for EPL Gb, Db, or Mb, fixed together by means of special fasteners according to 9.2 and the equipment marked with the separation marking as required by item e) of 29.13;

c) for EPL Gc or Dc, fixed together according to 9.1 and the equipment marked with the separation marking as required by item e) of 29.13.

Where they cannot be de-energized before separation because they are connected to a battery, the marking shall state the separation warning required by item f) of 29.13.

20.2 Explosive gas atmospheres

It is not necessary for plugs and socket outlets of EPL Gb or Gc to comply with the requirements of 20.1 if all of the following conditions are met:

– the part which remains energized is a socket outlet;

– there is a delay time for the separation of the plug and socket outlet such that the rated current flow ceases so no arc will occur on separation;

– the plug and socket outlet remain flameproof in accordance with IEC 60079-1 during the arc-quenching period while opening the test circuit specified in IEC 60079-1;

– the contacts remaining energized after separation are protected according to one of the specific types of protection listed in Clause 1.

20.3 Explosive dust atmospheres

The requirements of 20.1 apply in all cases.

20.4 Energized plugs

Plugs and components remaining energized when not engaged with a socket outlet are not permitted.

21 Supplementary requirements for luminaires

21.1 General

The source of light of luminaires shall be protected by a light-transmitting cover that may be provided with an additional guard.

A single eyebolt may be used as the mounting means of a luminaire designed for fixed installation only if this is an integral part of the luminaire, for example by being cast or welded to the enclosure or, if threaded, the eyebolt shall be locked by a separate means against loosening when twisted.

21.2 Covers for luminaires of EPL Mb, EPL Gb, or EPL Db

Covers giving access to the lampholder or other internal parts of luminaires for the purpose of re-lamping shall either be:

a) interlocked with a device which automatically disconnects all poles of the lampholder during the opening procedure; or

b) marked with the opening marking as required by item d) of 29.13.

In the case of a) above, where it is intended that some parts other than the lampholder will remain energized after operation of the disconnecting device, in order to minimize the risk of explosion, those energized parts shall be protected by either:

a) one of the appropriate types of protection (for the required EPL) listed in Clause 1, or

b) the means of protection given below:

- the disconnecting device shall be so arranged that it cannot be operated manually to inadvertently energize unprotected parts; and
- clearances and creepage distances between phases (poles) and to earth shall be in accordance with the requirements of IEC 60079-7; and
- an internal supplementary enclosure, which can be the reflector for the light source, which shall contain the energized parts and shall provide a degree of protection of at least IP20, according to IEC 60529; and
- marking on the internal supplementary enclosure as required by item h) of 29.13.
- For luminaires in Type of Protection “d”, the luminaires shall remain flameproof according to IEC 60079-1 until the switch has opened, and the switch shall not be closed until the Type of Protection “d” is restored

NOTE For Type of Protection “t”, re-lamping is not intended to be made at the time a dust cloud is present

21.3 Covers for luminaires of EPL Gc or EPL Dc

Covers giving access to the lampholder or other internal parts of luminaires for the purpose of re-lamping shall either be

a) interlocked with a device which automatically disconnects all poles of the lampholder during the opening procedure or,

b) marked with the opening marking as required by item d) of 29.13.

In the case of a) above, where it is intended that some parts other than the lampholder will remain energized after operation of the disconnecting device, in order to minimize the risk of explosion, those energized parts shall be protected by:

– clearances and creepage distances between phases (poles) and to earth in accordance with the requirements of IEC 60664-1 with over-voltage category II and pollution degree 3; and

– an internal supplementary enclosure, which can be the reflector for the light source, which contains the energized parts and provides a degree of protection of at least IP20, according to IEC 60529; and

– marking on the internal supplementary enclosure as required by item h) of 29.13.

21.4 Sodium lamps

Lamps containing free metallic sodium (for example, low-pressure sodium lamps in accordance with IEC 60192) are not permitted.

High-pressure sodium lamps (for example, in accordance with IEC 60662) may be used.

NOTE The use of lamps containing free metallic sodium is not permitted because of the risk of ignition from a broken lamp (occurring for example during lamp replacement) if the free metallic sodium should come into contact with water.

22 Supplementary requirements for caplights and handlights

22.1 Group I caplights

The requirements for caplights for use in mines susceptible to firedamp are contained in IEC 60079-35-1.

22.2 Group II and Group III caplights and handlights

Leakage of the electrolyte shall be prevented in all positions of the equipment.

Where the source of light and the source of supply are housed in separate enclosures, which are not mechanically connected other than by an electric cable; the cable glands and the connected cable shall be tested according to A.3.1 or A.3.2, as appropriate. The test shall be carried out using the cable which is to be used for connecting both parts. The type, dimensions and other relevant information about the cable which is to be used shall be specified in the manufacturer's documentation.

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

23 Equipment incorporating cells and batteries

23.1 General

The requirements in 23.2 to 23.12 shall apply for all cells and batteries incorporated into explosion-protected equipment.

23.2 Interconnection of cells to form batteries

Unless otherwise stated in the standard for the specific Type of Protection, batteries incorporated into explosion-protected equipment shall be formed only from cells connected in series.

NOTE The requirements for the specific Type of Protection may permit the connection of cells in parallel.

23.3 Cell types

Only cell types referred to in Table 13 or Table 14 shall be used.

Table 13 – Primary cells

IEC 60086-1 letter code	Positive electrode	Electrolyte	Negative electrode	Nominal voltage[1] V	Maximum open-circuit voltage[2] V
-	Manganese dioxide (MnO_2)	Ammonium chloride, zinc chloride	Zinc (Zn)	1,5	1,725
A	Oxygen (O_2)	Ammonium chloride, zinc chloride	Zinc (Zn)	1,4	1,55
B	Carbon monofluoride $(CF)_X$	Organic electrolyte	Lithium (Li)	3	3,7
C	Manganese dioxide (MnO_2)	Organic electrolyte	Lithium (Li)	3	3,7
E	Thionyl chloride ($SOCl_2$)	Non-aqueous inorganic	Lithium (Li)	3,6	3,9
F	Iron disulfide (FeS_2)	Organic electrolyte	Lithium (Li)	1,5	1,83
G	Copper (II) oxide (CuO)	Organic electrolyte	Lithium (Li)	1,5	2,3
L	Manganese dioxide (MnO_2)	Alkali metal hydroxide	Zinc (Zn)	1,5	1,65
P	Oxygen (O_2)	Alkali metal hydroxide	Zinc (Zn)	1,4	1,68
S	Silver oxide (Ag_2O)	Alkali metal hydroxide	Zinc (Zn)	1,55	1,63
W	Sulphur dioxide SO_2)	Non-aqueous organic salt	Lithium (Li)	3,0	3,0
Y	Sulfuryl chloride (SO_2Cl_2)	Non-aqueous	Lithium (Li)	3,9	4,1
Z	Nickel oxyhydroxide (NiOOH)	Alkali metal hydroxide	Zinc (Zn)	1,5	1,78

[1] Surface temperature rise tests conducted at this voltage.

[2] Voltage used for spark hazard assessment

NOTE 1 Not all cell constructions are suitable for all types of protection. Refer to the standard of the specific Type of Protection.

NOTE 2 Zinc/manganese dioxide cells are listed in IEC 60086-1, but not classified by a type letter.

NOTE 3 The source of electrochemistry information for this table is IEC 60086-1:2011

NOTE 4 The value of the nominal voltage is not verifiable; therefore it is only given as a reference.

NOTE 5 Recent research has found that some primary Lithium cells of sufficient capacity, particularly cells with a spiral wound construction, can be considered as potentially exothermic chemical reaction ignition sources.

Table 14 – Secondary cells

Type System ~Letter~	Positive electrode	Electrolyte	Negative Electrode	voltage[1] (per cell) V	Maximum open circuit voltage[2] (per cell) V
Lead Acid (flooded) ~None ~	Lead oxide	Sulfuric acid (SG 1,25 to 1,32)	Lead	2,2	2,67[a] 2,35[b]
Lead acid (VRLA) ~None ~	Lead oxide	Sulfuric acid (SG 1,25 to 1,32)	Lead	2,2	2,35[b]
Nickel-cadmium[3] ~K~&~KC~	Nickel oxy-hydroxide	Potassium hydroxide (SG 1,3)	Cadmium	1,3	1,55
Nickel metal hydride[3] ~H~	Nickel oxy-hydroxide	Potassium hydroxide	Metal hydride	1,3	1,55
Lithium ion	(LCO) $LiCoO_2$ Lithium Cobalt Oxide	Liquid solution containing a lithium salt and one or more organic solvents or gel electrolyte that is liquid solution mixed with polymer	Carbon	3,6	4,2
	(LCO) $LiCoO_2$ Lithium Cobalt Oxide		(LTO) $Li_4Ti_5O_{12}$ Lithium Titanium Oxide	2,3	2,7
	(LFP) $LiFePO_4$ Lithium Iron Phosphate		Carbon	3,3	3,6
	(LFP) $LiFePO_4$ Lithium Iron Phosphate		(LTO) $Li_4Ti_5O_{12}$ Lithium Titanium Oxide	2,0	2,1
	(NCA) $Li(NiCoAl)O_2$ Nickel Cobalt Aluminium		Carbon	3,6	4,2
	(NCA) $Li(NiCoAl)O_2$ Nickel Cobalt Aluminium		(LTO) $Li_4Ti_5O_{12}$ Lithium Titanium Oxide	2,3	2,7
	(NMC) $Li(NiMnCo)O_2$ Nickel Manganese Cobalt		Carbon	3,7	4,35
	(NMC) $Li(NiMnCo)O_2$ Nickel Manganese Cobalt		(LTO) $Li_4Ti_5O_{12}$ Lithium Titanium Oxide	2,4	2,85
	(LMO) $LiMn_2O_4$ Lithium Manganese Oxide		Carbon	3,6	4,3
	(LMO) $LiMn_2O_4$ Lithium Manganese Oxide		(LTO) $Li_4Ti_5O_{12}$ Lithium Titanium Oxide	2,3	2,8

[a] wet cell – cell containing an liquid electrolyte that can be replenished

[b] dry cell – cell containing an immobilized electrolyte

[1] Voltage figure is used for all assessments (e.g. temperature, creepage and clearance values) other than spark hazard assessment

[2] Voltage used for spark hazard assessment. If the cell manufacturer's data reflects a charging voltage higher than the value shown, the manufacturer's value shall be used.

[3] Chemistry uses constant current technique to charge.

NOTE 1 Not all cell constructions are suitable for all types of protection. Refer to the standard of the specific Type of Protection.

NOTE 2 The source of lead acid electrochemistry information is the Linden Handbook of Batteries, 4th edition.

NOTE 3 The source of nickel cadmium and nickel metal hydride electrochemistry information is IEC 61951-1, IEC 61951-2, IEC 60622, IEC 600623, and the Linden Handbook of Batteries, 4th edition.

NOTE 4 The source of lithium ion and lithium metal electrochemistry information is IEC 61960 and the Linden Handbook of Batteries, 4th edition.

NOTE 5 Recent research has found that some secondary Lithium ion cells of sufficient capacity, particularly cells with a $LiCoO_2$ positive electrode and spiral wound construction, can be considered as potentially strong oxidizers and exothermic chemical reaction ignition sources.

23.4 Cells in a battery

All cells in a battery shall be of the same electrochemical system, cell design and rated capacity and shall be made by the same manufacturer.

23.5 Ratings of batteries

All batteries shall be arranged and operated so as to be within the allowable limits defined by the cell or battery manufacturer.

23.6 Interchangeability

Primary and secondary cells or batteries shall not be used inside the same equipment enclosure if they are readily interchangeable.

23.7 Charging of primary batteries

Primary batteries shall not be re-charged. Where another voltage source exists inside equipment containing primary batteries and there is a possibility of interconnection, precautions shall be taken to prevent charging current passing through them.

23.8 Leakage

All cells shall be constructed, or arranged so as to prevent leakage of electrolyte, which would adversely affect the Type of Protection or components on which safety depends.

23.9 Connections

Only the battery manufacturer's recommended method(s) of making electrical connections to a battery shall be used.

23.10 Orientation

Where a battery is mounted inside equipment and the battery orientation is important for safe operation, the correct orientation of the equipment shall be indicated on the outside of the equipment enclosure.

NOTE Correct orientation of the battery is often important to prevent electrolyte leakage.

23.11 Replacement of cells or batteries

Where it is necessary for the user to replace cells or batteries contained within an enclosure, the relevant parameters to allow correct replacement shall be legibly and durably marked on

or inside the enclosure as detailed in 29.14, or detailed in the manufacturer's instructions in accordance with 30.2. That is, either the cell or battery manufacturer's name and part number, or the electrochemical system, nominal voltage and rated capacity.

23.12 Replaceable battery pack

Where it is intended for the user to replace the battery pack, the battery pack shall be legibly and durably marked on the outside of the battery pack as detailed in 29.14 and the battery pack replacement details shall be included in the manufacturer's instructions in accordance with 30.2.

Replaceable battery packs shall be one of the following:

- located completely inside the equipment enclosure;
- connected to the equipment and shall comply with the requirements for the applicable Type of Protection when disconnected from the equipment and shall be marked per item b) of 29.13;
- connected to the equipment and shall employ disconnecting means that comply with the requirements of Clause 20.

24 Documentation

The manufacturer shall prepare documentation that details the explosion safety aspects of the equipment necessary to determine compliance with this standard and any other applicable explosion safety standards.

NOTE This documentation is normally referred to as the schedule drawings.

25 Compliance of prototype or sample with documents

The prototypes or samples of the equipment subjected to the type verifications and tests shall comply with the manufacturer's documents referred to in Clause 24.

26 Type tests

26.1 General

The prototypes or samples shall be tested in accordance with the requirements for type tests of this standard and of the specific standards for the types of protection concerned. However, certain tests judged to be unnecessary, may be omitted from the testing programme. A record shall be made of all tests carried out and of the justification for those omitted.

It is not necessary to repeat the tests that have already been carried out on an Ex Component.

NOTE Due to the safety factors incorporated in the types of protection, the uncertainty of measurement inherent in good quality, regularly calibrated measurement equipment is considered to have no significant detrimental effect and need not be taken into account when making the measurements necessary to verify compliance of the equipment with the equipment requirements of the relevant part of IEC 60079.

26.2 Test configuration

Each test shall be made in the configuration of the equipment considered to be the most unfavourable taking into account the installation instructions.

26.3 Tests in explosive test mixtures

Tests in explosive mixtures shall be carried out as specified in relevant standards listed in Clause 1.

NOTE Commercially available gases and vapours with purity of 95 % or better is in general satisfactory for these tests. The effects of normal variations in the laboratory temperature and of atmospheric pressure and the effects of variations in the humidity of the explosive test mixture are acceptable because they have been found to have negligible effect.

26.4 Tests of enclosures

26.4.1 Order of tests

26.4.1.1 Metallic enclosures, metallic parts of enclosures and glass or ceramic parts of enclosures

Tests for metallic enclosures, metallic parts of enclosures and glass or ceramic parts of enclosures shall be performed in the following order:

– tests for resistance to impact (see 26.4.2);
– drop test, if applicable (see 26.4.3);
– tests for degrees of protection (IP) (see 26.4.5);
– any other tests required by this standard;
– any other test specific to the Type of Protection concerned.

Tests shall be made on the number of samples specified by each test method.

NOTE Where the Type of Protection of the degree of protection IP is provided by non-metallic sealing materials, other than glass or ceramics, the requirements of 26.4.1.2 will apply.

26.4.1.2 Non-metallic enclosures or non-metallic parts of enclosures

26.4.1.2.1 General

Tests for non-metallic enclosures or non-metallic parts of enclosures shall be performed in the following order. See Annex F for a flowchart providing guidance on the order of tests.

When the non-metallic material is glass or ceramic, the tests of 26.4.1.2 do not apply.

26.4.1.2.2 Group I equipment

The tests shall be made on samples as follows:

– Four samples shall be used. All four samples shall be submitted to the tests of thermal endurance to heat (see 26.8), then to the tests of thermal endurance to cold (see 26.9). Two samples shall then be submitted to the tests for resistance to impact (see 26.4.2), with the tests being conducted at the ‘upper test temperature’ (see 26.7.2). The other two samples shall also be submitted to the tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), but with the tests being conducted at the ‘lower test temperature’ (see 26.7.2). Any joint that is intended to be opened during installation or in normal operation shall be opened and re-closed in accordance with the manufacturer’s instructions. Subsequently, all four samples shall be submitted to the tests for degree of protection by enclosures (see 26.4.5), and then subjected to the appropriate tests specific to the Type of Protection concerned.
– Alternatively, only two samples may be used. In this case, both samples shall be submitted to the tests of thermal endurance to heat (see 26.8), then to thermal endurance to cold (see 26.9). Both samples shall then be submitted to the tests for resistance to impact (see 26.4.2), with the tests being conducted at the “upper test temperature” (see 26.7.2). Thereafter, both samples shall also be submitted to the tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), but with the tests now being conducted at the ‘lower test temperature’ (see 26.7.2). Any joint that is intended to be opened during installation or in normal operation shall be opened and re-closed in accordance with the manufacturer’s instructions. Subsequently, both samples shall be submitted to the tests for degree of protection by enclosures (see 26.4.5), and then subjected to the appropriate tests specific to the Type of Protection concerned. The order

of the tests at the “lower test temperature” and the “upper test temperature” may be interchanged.

NOTE As a result of the thermal endurance testing for either of the test sequences described above, condensation can occur inside the enclosure. Such condensation will need to be removed prior to ingress protection (IP) testing to ensure valid results.

– Two samples shall be submitted to the tests of resistance to oils and greases (see 26.11) then to the tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), then the tests for degrees of protection (IP) if applicable (see 26.4.5), and finally to the tests specific to the Type of Protection concerned.
– Two samples shall be submitted to the tests of resistance to hydraulic liquids for mining applications (see 26.11) then to tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), then the tests for degrees of protection (IP) if applicable (see 26.4.5), and finally to the tests specific to the Type of Protection concerned.

In the procedures and test sequences described above, the objective is to demonstrate the ability of the non-metallic material to maintain the specific Type of Protection listed in Clause 1 after exposure to extremes of temperature and harmful substances likely to be met in use. In an attempt to keep the number of tests to a minimum, it is not necessary to perform all of the tests specific to the Type of Protection on every sample if it is obvious that a sample has not been damaged in such a way as to impair the Type of Protection offered. Similarly, the number of samples can be reduced if it is possible for the exposure tests and protection-proving tests to be performed in parallel on the same two samples.

26.4.1.2.3 Group II and Group III equipment

Four samples shall be used. All four samples shall be submitted to the tests of thermal endurance to heat (see 26.8), then to the tests of thermal endurance to cold (see 26.9). Two samples shall then be submitted to the tests for resistance to impact (see 26.4.2), with the tests being conducted at the ‘upper test temperature’ (see 26.7.2). The other two samples shall also be submitted to the tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), but with the tests being conducted at the ‘lower test temperature’ (see 26.7.2). Any joint that is intended to be opened during installation or in normal operation shall be opened and re-closed in accordance with the manufacturer’s instructions. Subsequently, all four samples shall be submitted to the tests for degree of protection by enclosures (see 26.4.5), and then subjected to the appropriate tests specific to the Type of Protection concerned.

Alternatively, only two samples may be used. In this case, both samples shall be submitted to the tests of thermal endurance to heat (see 26.8), then to thermal endurance to cold (see 26.9). Both samples shall then be submitted to the tests for resistance to impact (see 26.4.2), with the tests being conducted at the ‘upper test temperature’ (see 26.7.2). Thereafter, both samples shall also be submitted to the tests for resistance to impact (see 26.4.2), then to the drop test if applicable (see 26.4.3), but with the tests now being conducted at the ‘lower test temperature’ (see 26.7.2). Any joint that is intended to be opened during installation or in normal operation shall be opened and re-closed in accordance with the manufacturer’s instructions. Subsequently, both samples shall be submitted to the tests for degree of protection by enclosures (see 26.4.5), and then subjected to the appropriate tests specific to the Type of Protection concerned. The order of the tests at the “lower test temperature” and the “upper test temperature” may be interchanged.

NOTE 1 As a result of the thermal endurance testing for either of the test sequences described above, condensation can occur inside the enclosure. Such condensation will need to be removed prior to ingress protection (IP) testing to ensure valid results.

NOTE 2 When only two samples are used and the equipment includes a light transmitting part of glass, the glass of each sample is subjected to one impact test at low temperature and subjected to another impact test at high temperature, resulting in two impacts to the glass of each sample.

NOTE 3 Glass parts of enclosures with cemented joints are subject to impact in order to confirm the adhesion of the cement to the glass and the enclosure. The glass is not required to be subjected to impact at both high and low

temperature, but there is no way to test the cement without the glass in place. Using the four sample option instead of the two sample option results in the minimum number of impact tests on the glass part.

26.4.2 Resistance to impact

The equipment shall be submitted to the effect of a test mass of 1 kg falling vertically from a height h. The height h is specified in Table 15 according to the application of the equipment. The mass shall be fitted with an impact head made of hardened steel in the form of a hemisphere of (25 ± 0.5) mm diameter.

The diameter of the test mass should not be significantly larger than the 25 mm impact head so that the impact head is not restricted from contacting portions of the equipment under test.

If a guide tube is used for the test mass, the diameter of the guide tube or pressure relief holes shall be such that the movement of the test mass is not restricted by the compression of air created by the dropping of the test mass.

Before each test, it is necessary to check that the surface of the impact head is in good condition.

The resistance to impact test shall be made on equipment which is completely assembled and ready for use; however, if this is not possible (for example, for light-transmitting parts), the test shall be made with the relevant parts removed but fixed in their mounting or an equivalent frame. Tests on an empty enclosure are permitted with appropriate justification in the documentation (see Clause 24).

The test shall be made on at least two samples of the equipment, see 26.4.1. The test shall be made at two separate places on each sample. For equipment with light-transmitting parts made of glass, only one of those two tests shall be on the glass.

The points of impact shall be the places considered likely to be the weakest and shall be on the external parts which may be exposed to impact. If the enclosure is protected by another enclosure, only the external parts of the assembly shall be subjected to the resistance to impact tests. For equipment with multiple materials or areas of concern, more than two samples or impact sites may need to be considered to adequately evaluate the impact resistance of the equipment.

The equipment shall be placed on a steel base so that the direction of the impact is normal to the surface being tested if it is flat, or normal to the tangent to the surface at the point of impact if it is not flat. The base shall have a mass of at least 20 kg or be rigidly fixed or inserted in the floor, for example, secured in concrete. Annex C gives an example of a suitable test rig.

When the impact head strikes the test sample, it may exhibit one or more “bounces”. The impact head shall not be removed from the surface of the test sample until it has come to rest.

Table 15 – Tests for resistance to impact

	Drop height $h^{\ 0}_{+0,01}$ m with 1 $^{\ 0}_{+0,01}$ kg mass			
Equipment grouping	**Group I**		**Group II or III**	
Risk of mechanical danger	**High**	**Low**	**High**	**Low**
a) Enclosures and external accessible parts of enclosures (other than light-transmitting parts)	2	0,7	0,7 [d]	0,4 [b d]
b) Guards, protective covers, fan hoods, cable glands	2	0,7	0,7	0,4 [b]
c) Light-transmitting parts of portable or transportable luminaires or handlights which have a surface area of 5 000 mm^2 or less and which are protected by an independent protruding rim with a minimum height of 2 mm [c]	0,7	0,4	0,4	[b]
d) Light-transmitting parts of portable or transportable luminaires or handlights without guard or light transmitting part which have a surface area of greater than 5 000 mm^2	2	0,7	0,7	[b]
e) Light-transmitting parts without guard	0,7	0,4	0,4 [d]	0,2 [b d]
f) Light-transmitting parts with guard having individual openings from 625 mm^2 to 2 500 mm^2; (tested without guard)[a]	0,4	0,2	0,2	0,1 [b]

[a] A guard for light-transmitting parts having individual openings from 625 mm^2 to 2 500 mm^2 reduces the risk of impact, but does not prevent impact. These requirements are also applicable to fixed, transportable, or portable luminaires.

[b] Group II or Group III, portable or transportable luminaires or handlights, shall only be tested for risk of mechanical danger “high”

[c] A protruding rim which is part of the enclosure and not part of the light transmitting part reduces the risk of impact, but does not prevent impact.

[d] Where a part of the equipment (such as a non-metallic overlay of a touch pad) serves multiple functions, such as a light-transmitting area and also as part of the enclosure, the function covering the largest area is used to determine which risk of mechanical danger row is applied.

When, at the request of the manufacturer, equipment is submitted to tests corresponding to the low risk of mechanical danger, it shall be marked with the symbol “X” to indicate this specific condition of use in accordance with item e) of 29.3.

The test shall be carried out at an ambient temperature of (20 ± 5) °C, except where the material data sheet of the metal shows it to have a reduction in resistance to impact at lower temperatures within the specified ambient range. In this case, the test shall be performed at the lower test temperature, in accordance with 26.7.2.

NOTE It is generally acknowledged that the impact resistance of glass and ceramic parts is not adversely affected by the temperature.

When the equipment has an enclosure or a part of an enclosure made of a non-metallic material other than glass or ceramic, including non-metallic fan hoods and ventilation screens in rotating electric machines, the test shall be carried out at the upper and lower test temperatures, in accordance with 26.7.2.

26.4.3 Drop test

In addition to being submitted to the resistance to impact test in accordance with 26.4.2, each portable or personal equipment sample, ready for use, shall be dropped four times from a height of at least 1 m onto a horizontal concrete surface. The position of the sample for the drop test shall be that which is considered to be the most unfavourable.

The drop test shall be conducted with any replaceable battery pack connected to the equipment.

For equipment with an enclosure which is of a metallic material, the test shall be carried out at a temperature of (20 ± 5) °C, except where the material data sheet shows it to have a reduction in resistance to impact at lower temperatures within the specified ambient range. In this case, the test shall be performed at the lower test temperatures, in accordance with 26.7.2.

For equipment which has enclosures or parts of enclosures made of non-metallic material, the tests shall be carried out at the lower test temperature in accordance with 26.7.2.

26.4.4 Acceptance criteria

The resistance to impact and drop tests shall not produce damage so as to invalidate the Type of Protection of the equipment.

Superficial damage, chipping to paint work, breakage of cooling fins or other similar parts of the equipment and small dents shall be ignored.

External fan hoods and ventilation screens shall resist the tests without displacement or deformation causing contact with the moving parts.

26.4.5 Degree of protection (IP) by enclosures

26.4.5.1 Test procedure

When a degree of protection is required by this standard or by other parts of this series for a specific Type of Protection, the test procedures shall be in accordance with IEC 60529, except for rotating electric machines which shall be in accordance with IEC 60034-5.

When tested in accordance with IEC 60529:

– enclosures shall be considered as belonging to “Category 1 enclosure” as specified in IEC 60529,
– the equipment shall not be energized,
– where applicable, the dielectric test specified in IEC 60529 shall be carried out at [(2 U_n + 1 000) ± 10 %] V RMS. applied between 10 s and 12 s, where U_n is the maximum rated or internal voltage of the equipment.

NOTE 1 The “category 1 enclosure” is defined in IEC 60529 and bears no relation to the “category 1” defined in the European directive 2014/34/EU (ATEX).

An evaluation for the first characteristic numeral, up to and including 6, implies compliance also with the requirements for all lower characteristic numerals. Up to and including second characteristic numeral 6, the evaluation implies compliance also with the requirements for all lower characteristic numerals. Evaluations for second characteristic numerals 7, 8, or 9 do not imply compliance with second characteristic numerals 5 or 6.

NOTE 2 It is acknowledged that there is an error with respect to this in IEC 60529, Ed 2.2.

When tested in accordance with IEC 60034-5, the rotating electrical machine shall not be energized,

NOTE 3 IECEx ExTAG DS 2012/005 provides background information on testing to confirm IP markings other than the minimum ratings required by the standards corresponding with the applied type(s) of protection, noting that an IP marking is not required as part of the explosion protection marking, but is often marked separate from the Ex marking string.

26.4.5.2 Acceptance criteria

For equipment tested in accordance with IEC 60529, the acceptance criteria shall be in accordance with IEC 60529 except where the manufacturer specifies acceptance criteria more onerous than those described in IEC 60529, for example, those in a relevant product standard. In this case, the acceptance criteria of the relevant product standard shall be applied unless it adversely affects explosion protection.

The acceptance criteria in IEC 60034-5 shall be applied to rotating electric machines insofar as compliance with an IEC explosion protection standard is concerned in addition to the conditions specified in IEC 60034-5.

Where a standard for equipment for explosive atmospheres specifies acceptance criteria for IPXX, these shall be applied instead of those in IEC 60529 or IEC 60034-5.

26.5 Thermal tests

26.5.1 Temperature measurement

26.5.1.1 General

For equipment which can normally be used in different positions, the temperature in each position shall be considered. When the temperature is determined for certain positions only, the equipment shall be marked with the symbol “X” to indicate this specific condition of use according to item e) of 29.3.

NOTE 1 The use of the symbol “X” is not appropriate for equipment that is likely to exist in uncontrolled positions. For example, mining headlights can operate for quite some time at angles that are not foreseen in normal operation (vertical) and can reach excessive temperatures.

The measuring devices (thermometers, thermocouples, etc.) and the connecting cables shall be selected and so arranged that they do not significantly affect the thermal behaviour of the equipment.

The final temperature shall be considered to have been reached when the rate of temperature rise does not exceed a rate of 2 K/h. If the service or surface temperature is determined with the required dust layer for EPL Da or a specified layer depth for EPL Db, the final temperature shall be considered to have been reached when the rate of temperature rise does not exceed a rate of 1 K/24 h.

Unless the manufacturer has specified a range of supply frequencies, it may be assumed that normal tolerances both of the supply in use and of the supply for test purposes is sufficiently small to be ignored.

NOTE 2 Some equipment can require the provision of integral temperature sensitive devices to limit temperatures.

26.5.1.2 Service temperature

The test to determine service temperatures shall be made at the rated voltage of the electrical equipment but without considering malfunctions.

The temperature of the hottest point of any part upon which the Type of Protection depends shall be determined.

Where the input voltage does not directly affect the temperature rise of the equipment or Ex Component, such as a terminal or a switch, the test current shall be 100 % of the rated current.

Where equipment rating is a range (for example, 100 – 250 V; or 240 V ± 10 %), the testing shall be performed at the highest or lowest value in the range, whichever results in the higher temperature rise.

26.5.1.3 Maximum surface temperature

The test to determine maximum surface temperature shall be performed under the most adverse ratings with an input voltage of 90 % of the rated voltage or at 110 % of the rated voltage of the electrical equipment whichever gives the maximum surface temperature.

For electric machines, determination of the maximum surface temperature may alternatively be conducted at the worst case test voltage within “Zone A” per IEC 60034-1. In this case, the equipment shall be marked with the symbol “X” in accordance with item e) of 29.3 and the specific condition of use shall include the information that the surface temperature determination was based on operation within “Zone A” (IEC 60034-1), typically ± 5 % of rated voltage. For electric machines operated from a converter, the test voltage variation, for maximum surface temperature determination shall be applied to the motor-converter system as a whole, i.e. applied to the converter input, not the motor input. See Annex E for additional information on the temperature rise testing of electric machines.

Where the input voltage does not directly affect the temperature rise of the equipment or Ex Component, such as a terminal or a switch, the test current shall be increased to 110 % of the rated current.

The tests to determine maximum surface temperature shall be performed without consideration of malfunctions unless specific malfunctions are specified by the requirements for the specific Type of Protection.

Where equipment rating is a range (for example, 100 – 250 V; or 240 V ± 10 %), the test shall be performed at 90 % of the lowest value in the range or at 110 % of the highest value in the range, whichever results in the higher temperature rise.

Unless the manufacturer has specified a range of supply frequencies, it may be assumed that normal tolerances both of the supply in use and of the supply for test purposes is sufficiently small to be ignored.

NOTE 1 Due to the voltage regulation properties of a converter, voltage variations at the input to the converter do not directly result in voltage variations at the output of the converter.

For electrical equipment of Group III, EPL Da, the test is conducted with the electrical equipment surrounded by at least a 200 mm layer of dust on all sides. The temperature measurements shall be made using a test dust having a thermal conductivity of no more than 0,10 W/(m×K) measured at (100 ± 5) ºC.

NOTE 2 Dusts that may be able to comply with the thermal conductivity used for this test include certain types of wood flour, cocoa powder, diatomaceous earth, expandable polystyrene beads and the like.

NOTE 3 Due to the insulating properties of the dust layer, power dissipations more than a few watts are generally impractical.

For electrical equipment of Group III, EPL Db, evaluated with a specified dust layer, (maximum surface temperature marking prefix $T_{\text{specified layer depth}}$), in accordance with 5.3.2.3.2 b), the equipment to be tested shall be surrounded on all sides by a dust thickness at least equal to the specified layer depth. The temperature measurements shall be made using a test dust having a thermal conductivity of no more than 0,10 W/(m×K) measured at (100 ± 5) ºC.

For electrical equipment of Group III, EPL Db, evaluated with a dust layer in accordance with 5.3.2.3.2 c), (maximum surface temperature marking prefix T_{L}), with the specific orientation(s) as given in the specific conditions of use, the test shall be carried out with the maximum layer

the equipment will hold, according to the specified equipment orientation, recognising that the dust thickness will not be uniform. The dust is to be applied by gently depositing, by use of a sieve or similar method, onto the surface(s), without any further compaction, until no more dust will accumulate. The temperature measurements shall be made using a test dust having a thermal conductivity of no more than 0,10 W/(m × K) measured at (100 ± 5) ºC.

The measured maximum surface temperature shall not exceed:

– for Group I equipment, those values as given in 5.3.2.1,
– for Group II equipment subjected to type testing for maximum surface temperature, the marked temperature or temperature class, less 5 K for temperature classes T6, T5, T4 and T3 (or marked temperatures ≤ 200 °C), and less 10 K for temperature classes T2 and T1 (or marked temperatures > 200 °C), Alternatively, for Group II equipment subjected to routine testing for maximum surface temperature, the temperature or temperature class marked on the electrical equipment,
– for Group III equipment, those values assigned, see 5.3.2.3.

26.5.2 Thermal shock test

Glass parts of luminaires and glass windows of equipment shall withstand, without visible damage, a thermal shock caused by a jet of water of about 1 mm diameter at a temperature (10 ± 5) °C sprayed on them when they are at not less than the maximum service temperature. The test shall be made on at least one sample.

NOTE This “jet of water” is frequently applied using a small (~10 cm^3) syringe with 10 °C water. Neither the distance from which the jet is applied, nor the pressure of application are considered to have a significant effect on the results.

26.5.3 Small component ignition test (Group I and Group II)

26.5.3.1 General

A small component tested to demonstrate that it shall not cause temperature ignition of a flammable mixture in accordance with item a) of 5.3.3, shall be tested in the presence of a specified gas/air mixture as described in 26.5.3.2.

26.5.3.2 Procedure

The test shall be carried out with the component either:

– mounted in the equipment as intended and precautions shall be taken to ensure that the test mixture is in contact with the component, or
– mounted in a model which ensures representative results. In this case, such a simulation shall take into account the effect of other parts of the equipment in the vicinity of the component being tested which affect the temperature of the mixture and the flow of the mixture around the component as a result of ventilation and thermal effects.

The component shall be tested under normal operation, or under the malfunction conditions specified in the standard for the Type of Protection which produces the highest value of surface temperature. The test shall be continued either until thermal equilibrium of the component and the surrounding parts is attained or until the component temperature drops. Where component failure causes the temperature to fall, the test shall be repeated five times using five additional samples of the component. Where, in normal operation or under the malfunction conditions specified in the standard for the Type of Protection, the temperature of more than one component exceeds the temperature class of the equipment, the test shall be carried out with all such components at their maximum temperature.

The safety margin required by 5.3.3 shall be achieved either by raising the ambient temperature at which the test is carried out or, where possible, by raising the temperature of the component under test and other relevant adjacent surfaces by the required margin.

For Group I, the test mixture shall be a homogenous mixture between 6,2 % and 6,8 %, v/v methane and air.

For T4 temperature classification, the mixture shall be either

a) a homogeneous mixture of between 22,5 % and 23,5 % v/v diethyl ether and air, or
b) a mixture of diethyl ether and air obtained by allowing a small quantity of diethyl ether to evaporate within a test chamber while the ignition test is being carried out.

For other temperature classifications, the choice of suitable test mixtures shall be at the discretion of the testing station.

If no ignition occurs during a test, the presence of the flammable mixture shall be verified by igniting the mixture by some other means.

26.5.3.3 Acceptance criteria

The component did not cause ignition of the flammable atmosphere, and the test mixture was shown to be flammable.

The appearance of a cool flame shall be considered as an ignition. Detection of ignition shall either be visual or by measurement of temperature, for example, by a thermocouple.

26.6 Torque test for bushings

26.6.1 Test procedure

Bushings used for connection facilities and which are subjected to torque during connection or disconnection of conductors shall be tested for resistance to torque.

The stem in the bushing, or the bushing when mounted, shall be subjected to a torque of the value given in Table 16.

Table 16 – Torque to be applied to the stem of bushing used for connection facilities

Diameter of the stem of the bushings	**Torque** Nm
M 4	2,0
M 5	3,2
M 6	5
M 8	10
M 10	16
M 12	25
M 16	50
M 20	85
M 24	130
Torque values for sizes other than those specified above may be determined from a graph plotted using these values. In addition, the graph may be extrapolated to allow torque values to be determined for stems of bushings larger than those specified.	

26.6.2 Acceptance criteria

When mounted, neither the stem in the bushing, nor the bushing itself, shall turn when the stem is subjected to a torque.

26.7 Non-metallic enclosures or non-metallic parts of enclosures

26.7.1 General

In addition to the relevant tests given in 26.1 to 26.6, non-metallic enclosures shall also satisfy the requirements in 26.8 to 26.15, as appropriate. The tests of 26.10 to 26.15 are independent tests performed on separate samples that are not required to be part of the test sequence for tests of enclosures, 26.4. Non-metallic parts of enclosures shall be tested together with the whole enclosure or with a representative model of the enclosure.

26.7.2 Test temperatures

When, according to this standard or to the specific standards listed in Clause 1, tests have to be carried out as a function of the upper and lower service temperature, these test temperatures shall be:

– for the upper temperature, the maximum service temperature (see 5.2) increased by at least 10 K but at most 15 K,

– for the lower temperature, the minimum service temperature (see 5.2) reduced by at least 5 K but at most 10 K.

26.8 Thermal endurance to heat

The thermal endurance to heat shall be determined by submitting the enclosures or parts of enclosures in non-metallic materials, on which the integrity of the Type of Protection depends, to tests according to Table 17.

Table 17 – Thermal endurance test

EPL	Service temperature Ts	Test condition	Alternative test condition
Ga Gb Da Db Ma Mb	Ts ≤ 70 °C	672 $^{+30}_{0}$ h at (90 ± 5) % RH, at Ts + 20 ± 2 K (but not less than 80 °C test temperature)	
	70 °C < Ts ≤ 75 °C	672 $^{+30}_{0}$ h at (90 ± 5) % RH at Ts + 20 ± 2 K	504 $^{+30}_{0}$ h at (90 ± 5) % RH at (90 ± 2) °C followed by 336 $^{+30}_{0}$ h dry at Ts +20 ± 2 K
	Ts > 75 °C	336 $^{+30}_{0}$ h at (90 ± 5) % RH at (95 ± 2) °C, followed by 336 $^{+30}_{0}$ h dry at Ts + 20 ± 2 K	504 $^{+30}_{0}$ h at (90 ± 5) % RH at (90 ±2) °C followed by 336 $^{+30}_{0}$ h dry at Ts +20 ± 2 K

EPL	Service temperature Ts	Test condition	Alternative test condition
Gc Dc	Ts ≤ 80 °C	672 $^{+30}_{0}$ h at (90 ± 5) % RH, at Ts + 10 ± 2 K	
	80 °C < Ts ≤ 85 °C	672 $^{+30}_{0}$ h at (90 ± 5) % RH at Ts + 10 ± 2 K	504 $^{+30}_{0}$ h at (90 ± 5) % RH at (90 ± 2) °C followed by 336 $^{+30}_{0}$ h dry at Ts +10 ± 2 K
	Ts > 85 °C	336 $^{+30}_{0}$ h at (90 ± 5) % RH at (95 ± 2) °C, followed by 336 $^{+30}_{0}$ h dry at Ts + 10 ± 2 K	504 $^{+30}_{0}$ h at (90 ± 5) % RH at (90 ±2) °C followed by 336 $^{+30}_{0}$ h dry at Ts +10 ± 2 K
Ts is the temperature defined in 5.2 and shall not include the increase stated in 26.7.2.			

At the conclusion of the test according to Table 17, the enclosures or parts of enclosures in non-metallic materials that were tested shall be subjected to (20 ± 5) °C at (50 ± 10) % relative humidity for 24 $^{+48}_{0}$ h, and then followed by the thermal endurance to cold test (26.9).

NOTE 1 The test values given in Table 17 include two test conditions. The conditions shown in the 2nd column were used in previous editions of this standard and allow previously obtained test results to remain valid for this edition. The conditions shown in the 3rd column have been added to allow testing at temperature/humidity conditions that are more readily achieved, although at an increased test time.

NOTE 2 It is generally acknowledged that glass and ceramic materials are not adversely affected by the thermal endurance to heat test, and testing may not be necessary.

NOTE 3 It is not a requirement of this standard that any specific ramp time between the stages of thermal endurance testing be applied. The test is not intended to be a thermal shock test.

26.9 Thermal endurance to cold

The thermal endurance to cold shall be determined by submitting the enclosures and parts of enclosures of non-metallic materials, on which the Type of Protection depends, to storage for 24 h $^{+2}_{0}$ in an ambient temperature corresponding to the minimum service temperature reduced according to 26.7.2.

NOTE It is generally acknowledged that glass and ceramic materials are not adversely affected by the thermal endurance to cold test, and testing may not be necessary.

26.10 Resistance to UV light

26.10.1 General

For plastic materials the test shall be made on six test bars of standard size (80 ± 2) mm × (10 ± 0,2) mm × (4 ± 0,2) mm according to ISO 179. The test bars shall be made under the same conditions as those used for the manufacture of the enclosure concerned; these conditions are to be stated in the test report of the equipment.

Where the preparation of test samples in accordance with ISO 179 is not practical due to the nature of the non-metallic material, an alternative test is permitted with the justification stated in the test report for the equipment.

For elastomers the test shall be made on six samples, where practicable the standard samples, as defined in ISO 48, per applied test method L, N, M or H. An alternative test is permitted with the justification stated in the test report for the equipment.

Where the preparation of test samples in accordance with ISO 48 is not practical due to the nature of the elastomers, or if specific elastomeric sealing profiles are used, the hardness measurement according to ISO 48 method CN, CM, CH or CL shall be used. An alternative test is permitted with the justification stated in the test report for the equipment.

NOTE The tests on plastic materials are generally destructive, so six un-exposed bars or samples are typically used to determine the initial properties of the material.

26.10.2 Light exposure

The test shall be made generally in accordance with ISO 4892-2 in an exposure chamber using a xenon lamp and a sunlight simulating filter system. The samples shall be exposed, without cycling, under dry conditions and at either a black standard temperature of (65 ± 3) °C or a black panel temperature of (55 ± 3) °C for between 1000 h and 1025 h.

NOTE The value of 65 °C black standard temperature is selected for compatibility with tests being performed in equipment specifically designed to operate in accordance with ISO 4892-2. The value of 55 °C black panel temperature is selected to ensure compatibility with results obtained for previous editions of IEC 60079-0. According to ISO 4892-2, both conditions are nearly identical, but any minor differences are generally too small to be relevant for the purpose of this test.

26.10.3 Acceptance criteria

For plastic materials the evaluation criteria is the impact bending strength in accordance with ISO 179. The impact bending strength following exposure in the case of an impact on the exposed side shall be at least 50 % of the corresponding value measured on the unexposed test bars. For plastic materials whose impact bending strength cannot be determined prior to exposure because no rupture has occurred, not more than three of the exposed test bars shall be allowed to break. Alternative acceptance criteria is permitted with the justification stated in the test report for the equipment.

For elastomers the evaluation criterion is the hardness measurement per ISO 48 with the same test method as selected for the preparation of the samples. The average hardness expressed in IRHD units as specified in ISO 48 on the exposed side of the 6 samples following exposure shall vary not more than 20 % of the corresponding value measured on the unexposed samples. Alternative acceptance criteria is permitted with the justification stated in the test report for the equipment.

26.11 Resistance to chemical agents for Group I equipment

The non-metallic enclosures and non-metallic parts of enclosures shall be submitted to tests of resistance to the following chemical agents:

– oils and greases;

– hydraulic liquids for mining applications.

The relevant tests shall be made on four samples of enclosure sealed against the intrusion of test liquids into the interior of the enclosure:

– two samples shall remain for (24 ± 2) h in oil IRM 902 according to ASTM D5964, at a temperature of (50 ± 2) °C;

– the other two samples shall remain for (24 ± 2) h in fire-resistant hydraulic fluid intended for operating at temperatures between –20 °C and +60 °C, comprising an aqueous solution of polymer in 35 % water at a temperature of (50 ± 2) °C.

At the end of the test, the enclosure samples concerned shall be removed from the liquid bath, carefully wiped and then stored for (24 ± 2) h in the laboratory atmosphere. Subsequently, each of the enclosure samples shall pass the tests of enclosures according to 26.4.

If one or more of the enclosure samples do not withstand these tests of enclosures after exposure to one or more of the chemicals, the enclosure shall be marked with the symbol "X" to indicate this specific condition of use according to item e) of 29.3, i.e. exclusion of exposure to specific chemicals during use.

26.12 Earth continuity

The material from which the enclosure is manufactured may be tested as a complete enclosure, part of an enclosure, or as a sample of the material from which the enclosure is made, provided that the relevant critical dimensions of the sample are the same as those of the enclosure.

The cable gland shall be represented by a 20 mm (nominal) diameter test bar manufactured from brass ($CuZn_{39}Pb_3$ or $CuZn_{38}Pb_4$) carrying an ISO metric thread with a tolerance class 6g, 1,5 mm pitch in accordance with IEC 60423. The length of the test bar shall ensure that at least one full thread remains free at each end when assembled, as shown in Figure 8.

Complete earth plates or parts of earth plates that are intended to be used with the enclosure shall be used for the purpose of this test. A clearance hole shall be provided in the earth plate for test purposes and shall be between 22 mm and 23 mm diameter. The method of assembly shall ensure that the screw thread of the test bar does not make contact directly with the inside of the clearance hole.

The clamping nuts shall be manufactured from brass ($CuZn_{39}Pb_3$ or $CuZn_{38}Pb_4$) and shall be provided with an ISO metric thread with a tolerance class 6H, 1,5 mm pitch in accordance with IEC 60423. The thickness of the nuts shall be 3 mm (nominal) and the dimension across the flats shall be 27 mm maximum.

The components are assembled as shown in Figure 8. The torque applied to each pair of the nuts, in turn, shall be 10 Nm (± 10 %).

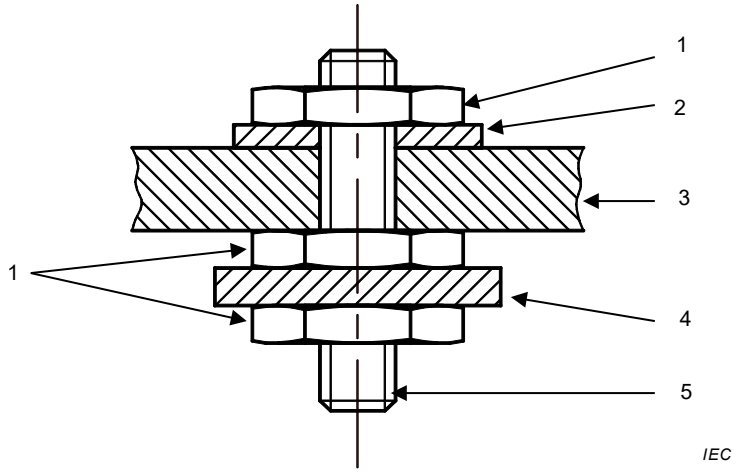
The hole in the wall (or part of the wall or the test sample) may be a plain through-hole or a tapped hole having a thread form compatible with the test bar.

After the test sample has been assembled it shall be subjected to the conditions for the test for thermal endurance to heat as described in 26.8.

This shall be followed by a further period of 336 $^{+30}_{0}$ h in an air oven at a temperature of at least 80 °C.

On completion of conditioning, the resistance between the earth plates or parts of earth plates shall be calculated by passing a direct current of 10 A to 20 A between the earth plates and measuring the voltage drop between them.

The non-metallic material that has been tested in this manner is deemed to be satisfactory if the resistance between the earth plates or parts of earth plates does not exceed 5 mΩ.



Components

1 nut
2 earth plate
3 enclosure wall (non-metallic)
4 earth plate or part of earth plate
5 test bar

Figure 8 – Assembly of test sample for earth-continuity test

26.13 Surface resistance test of parts of enclosures of non-metallic materials

The surface resistance shall be tested on the parts of enclosures if size permits, or on a test piece comprising a rectangular plate with dimensions in accordance with Figure 9. The test piece shall have an intact clean surface. Two parallel electrodes are painted on the surface, using a conducting paint with a solvent which has no significant effect on the surface resistance.

The test piece shall be cleaned with distilled water, then with isopropyl alcohol (or any other solvent that can be mixed with water and will not affect the material of the test piece or the electrodes), then once more with distilled water before being dried. Untouched by bare hands, it shall then be conditioned for at least 24 h at (23 ± 2) °C and (50 ± 5) % or (30 ± 5) % relative humidity, as applicable (See 7.4.2.a). The test shall be carried out under the same ambient conditions.

The DC voltage applied for (65 ± 5) s between the electrodes shall be (500 ± 25) V DC.

During the test, the voltage shall be sufficiently steady so that the charging current due to voltage fluctuation will be negligible compared with the current flowing through the test piece.

The surface resistance is the quotient of the DC voltage applied at the electrodes to the total current flowing between them.

If difficultly is encountered due to high currents at the 500 V DC test voltage; the test can be modified as follows. Apply a measuring voltage of (10 ± 0,5) V DC for (15 ± 5) s between the electrodes. If the resistance is below 10 MΩ, the measuring voltage shall be increased to (100 ± 5) V DC for (15 ± 5) s.

Dimensions in millimetres

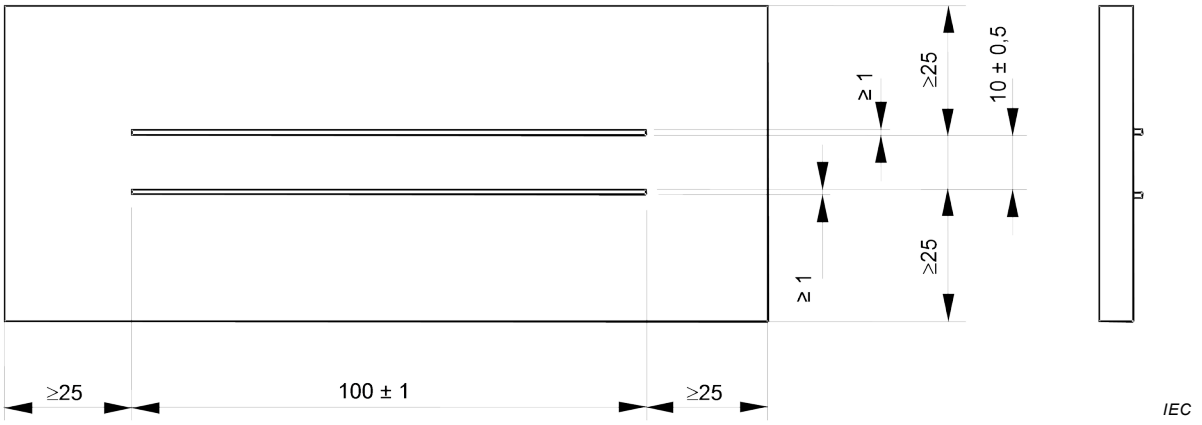


Figure 9 – Test piece with painted electrodes

26.14 Measurement of capacitance

26.14.1 General

The test shall be carried out on a fully assembled sample of the electrical equipment. The sample need not have been previously subjected to the tests for enclosures. The sample shall be conditioned in a climatic conditioning chamber for at least 1 h at a temperature of (23 ± 2) °C and a relative humidity of (50 ± 5) % RH. The sample under test shall be placed on an unearthed metal plate that significantly exceeds the area of the test sample. If the sample requires support, it may be held in position with clamps or pliers (preferably made of plastic), but shall not be held by hand. Other electrical equipment shall be kept as far as possible from the test sample. Connection leads shall be as short as possible. The positions of the samples are to be such that the exposed metallic test point being measured is as close as possible to the unearthed metal plate without contacting the plate. However, if the external metal part is in electrical contact with internal metal parts, it is necessary to measure the capacitance in all orientations of the equipment to ensure that the maximum capacitance has been determined.

Metallic plates with surface oxidation should be avoided as this may lead to erroneous results.

26.14.2 Test procedure

The capacitance between each exposed metallic part on the test sample and the metal plate is to be measured. Connect the negative measurement lead of the capacitance meter to the unearthed metal plate. The positive measurement lead of the capacitance meter should be kept as far as possible from the metal plate.

A battery powered capacitance meter may be necessary to ensure stable readings.

If a metallic part is not easily accessible to the meter leads, a screw may be inserted to extend the part and create a test point. The screw should not make electrical contact with any other internal metal part.

Stray capacitance should be minimized. Other electrical equipment should be kept as far away as possible.

The test procedure for the capacitance measurement is as follows:

1) Position the positive measurement probe of the capacitance meter 3 mm to 5 mm away from the metallic test point. Record the value of this stray capacitance in air to the nearest pF.

2) Place the positive measurement lead of the capacitance meter in contact with the metallic test point and record the value of the capacitance to the nearest pF.
3) Compute the difference between the measurements in steps 1) and 2), and record the value.
4) Repeat steps 1) through 3) two times for each test point.
5) Calculate the average capacitance from the three measurements obtained.

26.15 Verification of ratings of ventilating fans

The fan shall be supplied with the rated voltage and with the specified back pressure, if any. The maximum power, current and rotating speed shall be measured and shall comply with the rated values of the fan. The rated values of the motor and any other electrical parts of the fan, shall not be exceeded.

26.16 Alternative qualification of elastomeric sealing O-rings

The thickness t_0 of the sealing ring is measured at (20 ± 5) °C temperature. The ring is then compressed as intended in the complete equipment enclosure or in the test fixture.

The compressed sealing ring is then submitted to the tests for thermal endurance to heat (26.8) and thermal endurance to cold (26.9). The sealing ring shall then be removed from the adapter, or equipment, and be kept for at least 24 h $^{0}_{+2}$ at a temperature of (20 ± 5) ºC before the thickness t_1 of the O-ring is measured.

The compression set value c (See Figure 10) shall be calculated as follows:

$$c = (t_0 - t_1) / (t_0 - t_S) \times 100$$

t_0 is the initial thickness of the sealing ring measured at (20 ± 5) °C temperature

t_S is the thickness of the sealing ring when compressed as intended in the equipment.

t_1 is the thickness of the sealing ring measured at (20 ± 5) °C temperature after thermal endurance.

NOTE The compression set value describes the ability for the sealing ring to return to its initial dimension after being subject to compression.

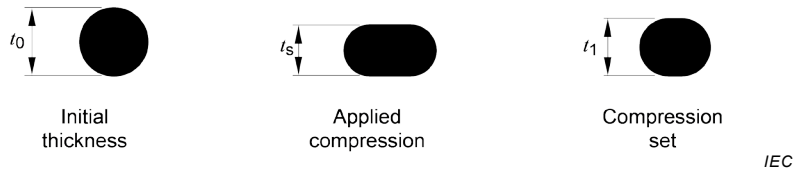


Figure 10 – Compression set of an O-ring

26.17 Transferred charge test

26.17.1 Test equipment

The following items are required:

1) A table or rigid sheet of dissipative material, e.g. untreated wood;

   NOTE 1 The correct use of a dissipative table surface guarantees a strong charge accumulation on the charged surface due to charge binding effects. After lifting the sample from the table the charges are no longer bound by opposite charges of the table yielding optimal conditions for discharging.

2) Cloths made of materials free from finishes from the positive and negative end of a triboelectric series large enough to avoid contact between the test sample and the fingers

of the testing person during the rubbing process, and a glove or other piece of smooth natural leather.

NOTE 2 See IEC TR 61340-1 for a triboelectric series.

NOTE 3 Suitable positive materials for tribocharging include smooth natural leather, sheep wool felt, polyamide cloth for rain coats, cotton, and cat fur. Suitable negative materials for tribocharging incude polyurethane and polyethylene table cloth.

3) A single pointed metal needle electrode or multi-needle electrodes having a connection of the electrode(s) to the minus pole of a high voltage power supply of 30 kV to 70 kV dc for corona charging.

4) One of the following or equivalent equipment for measuring charge transfer:

   a) A polished metal electrode of (25 ± 5) mm in diameter coupled to the 50 Ω input of an oscilloscope of at least 1 Gigasamples/s and 300 MHz bandwidth having a circular arranged earthed shunt resistance of (0,25 ± 0,05) Ω of at least 300 MHz in bandwidth, or

   b) A polished metal electrode of (25 ± 5) mm in diameter coupled to an earthed (100 ± 10) nF capacitor with a (15 ± 2) kΩ resistor in parallel, both connected to the input of a voltmeter automatically triggering and holding the highest value, or

   c) A polished metal electrode of (3 ± 1) mm in diameter in a smooth edged hole of (5 ± 1) mm in diameter of an earthed hollow sphere of (25 ± 5) mm in diameter, connected to an earthed (100 ± 10) nF capacitor at the input of a coulomb meter.

5) A flat round disk, less than 3 mm thickness, made of polytetrafluoroethylene (PTFE) with an area exceeding 20 000 mm^2 as a highly chargeable reference.

26.17.2 Test sample

The test shall be carried out on a fully assembled sample of the product or a material with the same fabrication parameters. This sample shall not have been previously subjected to other tests and may consist of any combination of insulating, conductive or dissipative materials.

It is advantageous to test the fully assembled product because charge binding effects, e.g. due to internal conductive items, may help to prevent hazardous discharges.

The sample shall be conditioned in an environmental conditioning chamber for at least 24 h at (23 ± 2) °C and (30 ± 5) % RH.

The test sample shall have an intact clean surface. As any solvent may leave conductive residue on the surface it is best to clean the surface with a brush only. This is especially important in cases where the surface is treated with special antistatic agents.

If, however, fingerprints or other dirt is visible on the surface and no special antistatic agents are used on the surface, the test sample shall be cleaned with 2-propanol (isopropyl alcohol) or any other suitable solvent that will not affect the material of the test sample and the electrodes, and then dried in air. It shall then be conditioned for at least 24 h at (23 ± 2) ºC and (25 ± 5) % relative humidity, without being touched again by bare hands.

26.17.3 Test procedure

Conductive parts shall be earthed during testing if earthing is required by the manufacturer's instructions.

The test is conducted as follows:

1) The correct operation of the measuring system shall be confirmed e.g. by test pulses of approximately 50 nC from a spherical electrode at the input of a calibrated electrostatic voltmeter of known input capacitance (e.g. 10 pF) and known applied voltage (e.g. 5 kV). Alternatively, a very short connection of a 1,5 V battery (typically 1,65 V) to the input of a

Coulombmeter (typically 100 pF input capacitance) shall display the transferred charge (typically 165 nC).

2) Check the test steps 3 to 11 with the reference PTFE disk and verify that at least 100 nC is obtained.

3) Rub the test sample with a material from the positive end of the triboelectric series at least one stroke per second with medium force (approximately 40 N), in direction away from the test person. The test surface shall not be contacted with the bare hand. Rubbing shall continue for (10 ± 1) s and shall be terminated with a hard rubbing stroke.

NOTE 1 Suitable positive materials for tribocharging include smooth natural leather, sheep wool felt, polyamide cloth for rain coats, cotton, and cat fur.

4) Lift the sample at least 20 cm away from the table using a method to minimize inadvertent discharge.

5) Discharge the sample as quickly as possible by slowly moving the spherical electrode of the measuring equipment towards the test sample until a discharge occurs. Particular attention shall be made to:

   a) Discharge the large surface areas and small conductive items.

   b) Discharges occurring at gaps less than 2 mm for IIA, 1 mm for IIB and 0,5 mm for IIC are less incendive than expected by their transferred charge due to quenching effects at the electrodes.

6) Quickly remove the sample from the vicinity of the electrode.

7) Read the value from the display or integrate the recorded current (horizontal setting typically 40 ns/div) and multiply it with the known calibration factor.

8) Repeat the test nine times.

9) Repeat steps 3-8 with a material from the negative end of the triboelectric series.

NOTE 2 Suitable negative materials for tribocharging include polyurethane and polyethylene table cloth.

10) Repeat steps 3-8 with a second material from the positive end of the triboelectric series

11) Repeat steps 3-8 with a third material. Alternatively, repeat steps 3-8, but replace step 3) with hitting the sample five times with the smooth part of a leather glove.

12) Check whether the test sample contains insulating parts backed with a conductor or is dissipative or conductive. If yes continue with 15, if no go to step 13.

NOTE 3 This is necessary to ensure that propagating brush discharges, which damage the measuring equipment, cannot occur.

13) Charge the sample by positioning the corona electrode slightly above the test sample and charge it with small circular motion. Circular motion is not necessary in case of a multi-needle electrode. Remove the electrode after approximately 5 s far away from the sample while the high voltage is still applied in order to avoid back spraying of charges from the charged sample to the electrode.

14) Continue with steps 4 to 8 until ten complete tests have been completed.

15) End of test

27 Routine tests

The manufacturer shall also carry out any routine tests required by any of the standards listed in Clause 1 which were used for the examination and testing of the equipment.

28 Manufacturer's responsibility

28.1 Conformity with the documentation

The manufacturer shall carry out the verifications or tests necessary to ensure that the equipment produced complies with the documentation.

NOTE 1 It is not the intent of this subclause to require 100 % inspection of parts. Statistical methods are often employed to verify compliance.

NOTE 2 For further information see ISO/IEC 80079-34.

28.2 Certificate

The manufacturer shall prepare, or have prepared, a certificate confirming that the equipment is in conformity with the requirements of this document along with other applicable parts and additional standards mentioned in Clause 1. The certificate can relate to Ex Equipment or an Ex Component.

An Ex Component certificate (Identified by the symbol “U” suffix to the certificate number) is prepared for parts of equipment that are incomplete and require further evaluation prior to incorporation in Ex Equipment. Information necessary to correctly apply the Ex Component shall be included in the Schedule of Limitations on the Certificate.

An Ex Component certificate shall state that it is not an Ex Equipment certificate.

28.3 Responsibility for marking

By marking the equipment in accordance with Clause 29, the manufacturer attests on his own responsibility that:

– the equipment has been constructed in accordance with the applicable requirements of the relevant standards in safety matters,
– the routine verifications and routine tests in 28.1 have been successfully completed and that the product complies with the documentation.

29 Marking

29.1 Applicability

It is essential that the system of marking indicated below only be applied to Ex Equipment or Ex Components which comply with the applicable standards for the types of protection listed in Clause 1.

29.2 Location

The Ex Equipment shall be legibly marked on a main part of the Ex Equipment and the marking shall be visible, from the exterior, prior to the installation of the Ex Equipment.

NOTE 1 The marking is intended to be in a location that is likely to be visible after installation of the Ex Equipment.

NOTE 2 Where the marking is located on a removable part of the Ex Equipment, a duplicated marking on the interior of the Ex Equipment can be useful during installation and maintenance by helping to avoid confusion with similar Ex Equipment. See 29.11 and 29.12 for additional guidance on extremely small equipment and Ex Components.

29.3 General

The marking shall include the following:

a) the name of the manufacturer or his registered trade mark;
b) the manufacturer's type identification;
c) a serial number; except for
   – connection accessories (cable gland, blanking element, thread adaptor, or bushings);
   – very small equipment on which there is limited space;

   (The batch number can be considered to be an alternative to the serial number.)

d) the name or mark of the certificate issuer and the certificate reference in the following form: the last two figures of the year of the certificate followed by a "." followed by a unique four character reference for the certificate in that year;

NOTE 1 For some regional third-party certification, the separating character "." is often replaced by another separating designator such as "ATEX".

e) if it is necessary to indicate specific conditions of use, the symbol "X" shall be placed after the certificate reference. An advisory marking may appear on the equipment as an alternative to the requirement for the "X" marking. A reference to a specific instruction document containing the detailed information may appear on the equipment as an alternative to the requirement for the "X" marking;

NOTE 2 It is the intent that the requirements of the Specific Conditions of Use are passed to the user together with any other relevant information.

f) the specific Ex marking for explosive gas atmospheres, see 29.4, or for explosive dust atmospheres, see 29.5. The Ex marking for explosive gas atmospheres and explosive dust atmospheres shall be separate and not combined;

g) any additional marking prescribed in the specific standards for the types of protection concerned, as in Clause 1.

NOTE 3 Additional marking may be required by the applicable industrial safety standards for construction of the equipment.

NOTE 4 IECEx ExTAG DS 2012/005 provides background information on testing to confirm IP markings other than the minimum ratings required by the standards corresponding with the applied type(s) of protection, noting that an IP marking is not required as part of the explosion protection marking, but is often marked separate from the Ex marking string.

29.4 Ex marking for explosive gas atmospheres

The Ex marking shall include the following:

a) the symbol Ex, which indicates that the Ex Equipment corresponds to one or more of the types of protection which are the subject of the specific standards listed in Clause 1;

b) the symbol for each Level of Protection used:
   - "da": flameproof enclosures, (for EPL Ga or Ma)
   - "db": flameproof enclosures, (for EPL Gb or Mb)
   - "dc": flameproof enclosures, (for EPL Gc)
   - "eb": increased safety, (for EPL Gb or Mb)
   - "ec": increased safety, (for EPL Gc)
   - "ia": intrinsic safety, (for EPL Ga or Ma)
   - "ib": intrinsic safety, (for EPL Gb or Mb)
   - "ic": intrinsic safety, (for EPL Gc)
   - "ma": encapsulation, (for EPL Ga or Ma)
   - "mb": encapsulation, (for EPL Gb or Mb)
   - "mc": encapsulation, (for EPL Gc)
   - "nA": non-sparking, (for EPL Gc)
   - "nC": protected sparking, (for EPL Gc)
   - "nR": restricted breathing, (for EPL Gc)
   - "ob": liquid immersion, (for EPL Gb)
   - "oc": liquid immersion, (for EPL Gc)
   - "op is": optical radiation, inherently safe (for EPL Ga or Gb or Gc or Ma or Mb)
   - "op pr": optical radiation, protected fibre (for EPL Gb or Gc or Mb)
   - "op sh": optical radiation, interlock (for EPL Ga or Gb or Gc or Ma or Mb)

– “pv”: pressurization, (for EPL Gb or Gc)
– “pxb”: pressurization, (for EPL Gb or Mb)
– “pyb”: pressurization, (for EPL Gb)
– “pzc”: pressurization, (for EPL Gc)
– “q”: powder filling, (for EPL Gb or Mb)
– “sa”: special protection (for EPL Ga or Ma)
– “sb”: special protection (for EPL Gb or Mb)
– “sc”: special protection (for EPL Gc)

c) the symbol of the group:
   – I for Ex Equipment for mines susceptible to firedamp;
   – IIA, IIB or IIC for Ex Equipment for places with an explosive gas atmosphere other than mines susceptible to firedamp.

     When the Ex Equipment is for use only in a particular gas, the chemical formula or the name of the gas in parentheses.

     When the Ex Equipment is for use in a particular gas in addition to being suitable for use in a specific equipment group, the chemical formula shall follow the equipment group and be separated with the symbol “+”, for example, “IIB + H_2”;

d) for Group II Ex Equipment, the symbol indicating the temperature class. Where the manufacturer wishes to specify a maximum surface temperature between two temperature classes, he may do so by marking that maximum surface temperature in degrees Celsius alone, or by marking both that maximum surface temperature in degrees Celsius and, in parentheses, the next highest temperature class, for example, T1 or 350 °C or 350 °C (T1).

   Group II Ex Equipment, having a maximum surface temperature greater than 450 °C, shall be marked only with the maximum surface temperature in degrees Celsius, for example, 600 °C.

   Where the Group II Ex Equipment has multiple temperature classes, e.g. for multiple ambient temperature ranges, and it is impractical to include the complete information in the marking, or where there are external sources of heating / cooling (See 5.1.2);

   - the complete temperature class information shall be included in the certificate and the marking shall include the symbol “X” to indicate this specific condition of use according to item e) of 29.3, and
   - the temperature class range shall be shown in the marking with the lower and upper limits of the temperature class separated by “…”, e.g. “T6...T3”.

   Group II Ex Equipment, marked for use in a particular gas, need not have a temperature class or maximum surface temperature marking.

   Ex Equipment cable glands, Ex Equipment blanking elements, and Ex Equipment thread adapters need not be marked with a temperature class or maximum surface temperature in degrees Celsius.

e) the Equipment Protection Level (EPL), “Ga”, “Gb”, “Gc”, “Ma”, or “Mb” as appropriate.

   NOTE 1 The EPL marked on the Ex Equipment may be more restrictive than that normally applied for a specific Type of Protection to account for other aspects of the equipment such as material limitations. For example Ex ia IIC T4 Gb, where the Ex Equipment was constructed of aluminium in a greater content than permitted by 8.3.

f) Where appropriate according to 5.1.1, the marking shall include either the symbol T_a or T_{amb} together with the range of ambient temperature or the symbol “X” to indicate this specific condition of use according to item e) of 29.3. If the Ex Equipment is also marked for use in explosive dust atmospheres and the ambient temperature range rating is identical, only one marking of ambient temperature range need appear.

The Ex marking string of items a) to e) according to 29.4 shall be placed in the order in which they are given in 29.4 and shall each be separated by a small space.

For associated apparatus suitable for installation in a hazardous area, and where the energy limitation is provided inside the Ex Equipment in the hazardous area, the symbols for the Level of Protection and EPL shall be enclosed within square brackets, for example, Ex db [ia Ga] IIC T4 Gb. When the equipment group of the associated apparatus differs from that of the equipment, the equipment group of the associated apparatus shall be enclosed within the square brackets, for example, Ex db [ia IIC Ga] IIB T4 Gb.

NOTE 2 A typical example is a shunt diode safety barrier located inside a flameproof enclosure.

For associated apparatus suitable for installation in a hazardous area, and where the energy limitation is provided from outside the Ex Equipment in a hazardous area, the symbols for the Type of Protection shall not be enclosed within square brackets, for example, Ex db ia IIC T4 Gb.

NOTE 3 A typical example is a flameproof luminaire with an intrinsically safe photocell connected to a safe area.

For associated apparatus not suitable for installation in a hazardous area, the symbol Ex and the symbol for the Level of Protection and EPL shall be enclosed within the same square brackets, for example, [Ex ia Ga] IIC.

For Ex Equipment that includes both associated apparatus and intrinsically safe apparatus with no connections required to be made to the intrinsically safe part of the Ex Equipment by the user, the “associated apparatus” marking shall not appear unless the Equipment protection Levels differ. For example, Ex db ib IIC T4 Gb and not Ex db ib [ib Gb] IIC T4 Gb, but Ex db ia [ia Ga] IIC T4 Gb is correct for differing EPLs.

NOTE 4 For associated apparatus not suitable for installation in a hazardous area, a temperature class is not included.

For Ex associated equipment suitable for installation in a hazardous area, the symbols for the Level of Protection of the Ex associated equipment and the EPL shall be enclosed within square brackets, for example, Ex db [pxb Gb] IIC T4 Gb. If both associated apparatus and associated equipment are provided, the symbols for the Levels of Protection and EPL are shown within separate square brackets, for example, Ex db [ib Gb] [pxb Gb] IIC T4 Gb.

For Ex associated equipment not suitable for installation in a hazardous area, the symbol Ex and the symbol for the Level of Protection of the Ex associated equipment and the EPL shall be enclosed within the same square brackets, for example, [Ex pxb Gb]. If both associated apparatus and Ex associated equipment are provided, the symbols for the Levels of Protection and EPL are shown within separate square brackets, for example, [Ex ib Gb] [Ex pxb Gb] IIC.

Where the equipment group is different for the Ex associated equipment and the Ex Equipment, the Equipment Group shall also be shown for example, Ex db [ib IIC Gb] [pxb Gb] IIB T4 Gb.

NOTE 5 Ex associated equipment, not for installation within the hazardous area, will not include a temperature class.

29.5 Ex marking for explosive dust atmospheres

The Ex marking shall include the following:

a) the symbol Ex, which indicates that the Ex Equipment corresponds to one or more of the types of protection which are the subject of the specific standards listed in Clause 1;

b) the symbol for each Level of Protection used:
   - “ia”: intrinsic safety, (for EPL Da)
   - “ib”: intrinsic safety, (for EPL Db)
   - “ic”: intrinsic safety, (for EPL Dc)

- “ma“: encapsulation, (for EPL Da)
- “mb”: encapsulation, (for EPL Db)
- “mc”: encapsulation, (for EPL Dc)
- “op is”: optical radiation, inherently safe (for EPL Da or Db or Dc)
- “op pr”: optical radiation, protected fibre (for EPL Db or Dc)
- “op sh”: optical radiation, interlock (for EPL Da or Db or Dc)
- “pxb”: pressurization, (for EPL Db)
- “pyb”: pressurization, (for EPL Db)
- “pzc”: pressurization, (for EPL Dc)
- “sa”: special protection (for EPL Da)
- “sb”: special protection (for EPL Db)
- “sc”: special protection (for EPL Dc)
- “ta”: protection by enclosure, (for EPL Da)
- “tb”: protection by enclosure, (for EPL Db)
- “tc”: protection by enclosure, (for EPL Dc)

c) the symbol of the group:
   - IIIA, IIIB or IIIC for Ex Equipment for places with an explosive dust atmosphere;

d) the maximum surface temperature marking, according to the assigned EPL;
   - For EPL Da the maximum surface temperature shall be shown as a temperature value in degrees Celsius and the unit of measurement °C, with the layer depth 200 mm indicated as a subscript (for example, T_{200} 320 °C). As the determination of the maximum surface temperature for Da without a layer is not permitted, the maximum surface temperature without a layer of dust cannot be marked.

     NOTE 1 Dust depth of more than 200 mm does not give rise to a further temperature increase that would need to be taken into account.

   - For EPL Db and EPL Dc, tested without a layer of dust, the maximum surface temperature shall be shown in degrees Celsius and the unit of measurement °C preceded with the letter “T”, (e.g. T90 °C).
   - For EPL Db, where appropriate according to 5.3.2.3.2 b), the maximum surface temperature $T_{\text{max layer of dust}}$ shall also be shown, in addition to the marking without a layer of dust, as a temperature value in degrees Celsius and the unit of measurement °C, with the specified layer depth in mm, indicated as a subscript, (e.g. T_{150} 320 °C).
   - For EPL Db, where appropriate according to 5.3.2.3.2 c), the maximum surface temperature T_L shall also be shown, in addition to the marking without a layer of dust, as a temperature value in degrees Celsius and the unit of measurement °C, with the layer in a specified orientation *L* indicated as a subscript, (e.g. T_L 320 °C).

   Where the Group III Ex Equipment has multiple maximum surface temperatures, e.g. for multiple ambient temperature ranges, and it is impractical to include the complete information in the marking, or where there are external sources of heating / cooling (See 5.1.2):

   - the complete maximum surface temperature information shall be included in the certificate and the marking shall include the symbol “X” to indicate this specific condition of use according to item e) of 29.3, and
   - the maximum surface temperature range shall be shown in the marking with the lower and upper limits of the surface temperature separated by “…”, for example, “T80 °C…T195 °C”.

   Ex Equipment cable glands, Ex Equipment blanking elements, and Ex Equipment thread adapters need not be marked with a maximum surface temperature;

e) the Equipment Protection Level (EPL), “Da”, “Db”, or “Dc”, as appropriate;

NOTE 2 The EPL marked on the Ex Equipment may be more restrictive than that normally applied for a specific Type of Protection to account for other aspects of the equipment such as material limitations. For example Ex ia IIIC T135°C Dc, where the Ex Equipment was constructed of materials in a greater content than permitted by 8.4.

f) where appropriate according to 5.1.1, the marking shall include either the symbol T_a or T_{amb} together with the range of ambient temperature or the symbol "X" to indicate this specific condition of use according to item e) of 29.3. If the Ex Equipment is also marked for use in explosive gas atmospheres and the ambient temperature range rating is identical, only one marking of ambient temperature range need appear.

The Ex marking string of items a) to e) according to 29.5 shall be placed in the order in which they are given in 29.5 and shall each be separated by a small space.

For associated apparatus suitable for installation in a hazardous area, and where the energy limitation is provided inside the Ex Equipment in the hazardous area, the symbols for the Level of Protection shall be enclosed within square brackets, for example, Ex tb [ia Da] IIIC T100 °C Db. When the equipment group of the associated apparatus differs from that of the Ex Equipment, the equipment group of the associated apparatus shall be enclosed within the square brackets, for example, Ex tb [ia IIIC Da] IIIB T100 °C Db.

NOTE 3 A typical example is a shunt diode safety barrier located inside a dust-protected enclosure.

For associated apparatus suitable for installation in a hazardous area, and where the energy limitation is provided from outside the Ex Equipment in a hazardous area, the symbols for the Type of Protection shall not be enclosed within square brackets, for example, Ex ia tb IIIC T100 °C Db.

NOTE 4 A typical example is a dust-protected luminaire with an intrinsically safe photocell connected to a safe area.

For associated apparatus not suitable for installation in a hazardous area, the symbol Ex, the symbol for the Level of Protection, and the EPL shall be enclosed within the same square brackets, for example, [Ex ia Da] IIIC.

For equipment that includes both associated apparatus and intrinsically safe apparatus with no connections required to be made to the intrinsically safe part of the equipment by the user, the associated apparatus marking shall not appear unless the EPLs differ. For example, Ex ib tb IIIC T100 °C Db and not Ex ib tb [ib Db] IIIC T100 °C Db, but Ex ia tb [ia Da] IIIC T100 °C Db is correct for differing EPLs.

NOTE 5 For associated apparatus not suitable for installation in a hazardous area, a temperature marking is not included.

For Ex associated equipment suitable for installation in a hazardous area, the symbols for the Level of Protection of the Ex associated equipment and the EPL shall be enclosed within square brackets, for example, Ex tb [pxb Db] IIIC T135°C Db. If both associated apparatus and Ex associated equipment are provided, the symbols for the Levels of Protection and EPL are shown within separate square brackets, for example, Ex tb [ib Db] [pxb Db] IIIC T135°C Db.

For Ex associated equipment not suitable for installation in a hazardous area, the symbol Ex, the symbol for the Level of Protection of the Ex associated equipment, and the EPL shall be enclosed within the same square brackets, for example, [Ex pxb Db]. If both associated apparatus and Ex associated equipment are provided, the symbols for the Levels of Protection and EPL are shown within separate square brackets, for example, [Ex ib Db] [Ex pxb Db] IIIC.

Where the equipment group is different for the Ex associated equipment and the Ex Equipment, the Equipment Group shall also be shown for example, Ex tb [ib IIIC Db] [pxb Db] IIIB T135°C Db

NOTE 6 Ex associated equipment, not for installation within the hazardous area, will not include a temperature class.

29.6 Combined types (or levels) of protection

Where different types (or levels) of protection are employed for different parts of Ex Equipment or an Ex Component, the Ex marking shall include the symbols for all of the Types (or Levels) of Protection employed. The symbols for the types of protection shall appear in alphabetical order, with small separating spaces. When associated apparatus is incorporated, the symbols for the type (or level) of protection, including the square brackets as applicable, shall follow those symbols of the type (or level) of protection for the equipment.

29.7 Multiple types of protection

Ex Equipment may be designed using multiple types of protection so that it is suitable for installation in different ways, using the appropriate installation requirements for the selected Type of Protection. For example, Ex Equipment which is designed to comply simultaneously with the equipment requirements for “i” and also with the equipment requirements for “d” or “e”; may be installed, according to the selection of the installer/user.

In this case:

– each respective Ex marking shall be separately indicated on the Ex Equipment marking and except in the case of Ex Equipment cable glands, Ex Equipment blanking elements, and Ex Equipment thread adapters, shall be prefixed by a place for an identification marking to allow the selected Ex marking to be identified at the time of installation,

– each respective Ex marking shall be separately indicated on the certificate.

When a single certificate is prepared with each Ex marking shown individually in the certificate, the applicable marking and any variation in the parameters or specification for each of the different Ex markings shall be shown without ambiguity.

When a separate certificate is prepared for each Ex marking, all the relevant parameters or specifications shall be provided in the certificate for the individual Ex marking.

29.8 Ga equipment using two independent Gb types (or levels) of protection

Where two independent types of protection, with EPL Gb, are employed for the same piece of equipment in order to achieve EPL Ga, the Ex marking shall include the symbols for the two types (or levels) of protection employed with the symbols for the types (or levels) of protection joined with a “+”. See IEC 60079-26.

29.9 Boundary wall

For equipment which is intended to be installed in the boundary wall between an area requiring EPL Ga or Da and a less hazardous area; both Levels of Protection and both EPLs are marked on the label, each separated by a slash “/”, for example:

Ex ia/db IIC T6 Ga/Gb, or (See IEC 60079-26)

Ex ia/tb IIIC T85°C Da/Db

29.10 Ex Components

Ex Components, according to Clause 13, shall be legibly marked and the marking shall include the following:

a) the name or the registered trade mark of the manufacturer;

b) the manufacturer's type identification;

c) the symbol Ex;

d) the symbol for each Type (or Level) of Protection used;

e) the symbol of the group of the equipment of the Ex Component;

f) the name or mark of the issuer of the certificate, and the number of the certificate;

g) the symbol “U”;

NOTE 1 The symbol “X” is not used.

h) the additional marking prescribed in the specific standard for the types of protection concerned, as in Clause 1;

NOTE 2 Additional marking may be required by the standards for construction of the equipment.

i) as much of the remaining marking information per 29.4 or 29.5, as applicable, as can be accommodated.

The Ex marking for explosive gas atmospheres and explosive dust atmospheres shall be separate and not combined.

The Ex marking of enclosures as Ex Components shall not be marked externally. Only the information of bullet point a) and b) may be marked externally. The internal marking need not be permanent. The internal markings may be omitted if the enclosure (as Ex Component) manufacturer is also the holder of the equipment certificate, and indicated as such in the Schedule of Limitations of the Ex Component certificate.

29.11 Small Ex Equipment and small Ex Components

On small Ex Equipment and on Ex Components where there is limited space, a reduction in the marking is permitted. The following lists the minimum marking that is required on the Ex Equipment or Ex Component:

a) the name or registered trademark of the manufacturer;

b) the manufacturer’s type identification. The type identification is permitted to be abbreviated or omitted if the certificate reference allows identification of the specific type;

c) the name or mark of the issuer of the certificate, and the number of the certificate;

d) the symbol “X” (Ex Equipment only, when appropriate) or “U” (Ex Components only);

NOTE The symbols “X” and “U” are never used together.

e) As much of the remaining marking information per 29.4 or 29.5, as applicable, as can be accommodated.

29.12 Extremely small Ex Equipment and extremely small Ex Components

In the case of extremely small Ex Equipment and extremely small Ex Components where there is no practical space for marking, a marking intended to be linked to the Ex Equipment or Ex Component is permitted. This marking shall be identical to the marking of 29.3, 29.4, and 29.5, as applicable, shall appear on a label provided with the Ex Equipment or Ex Component for affixing adjacent to the Ex Equipment or Ex Component.

29.13 Warning markings

Where any of the following warning markings are required on the equipment, the text as described in Table 18, following the word “WARNING,” may be replaced by technically equivalent text. Multiple warnings may be combined into one equivalent warning.

Table 18 – Text of warning markings

	Reference	WARNING marking
a)	6.3	WARNING – AFTER DE-ENERGIZING, DELAY *Y* MINUTES BEFORE OPENING (*Y* being the value in minutes of the delay required)
b)	6.3, 23.12	WARNING – DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE IS PRESENT
c)	18.2	WARNING – DO NOT OPERATE UNDER LOAD
d)	18.4 b), 21.2 b, 21.3 b)	WARNING – DO NOT OPEN WHEN ENERGIZED
e)	20.1 b)	WARNING – DO NOT SEPARATE WHEN ENERGIZED
f)	20.1 b)	WARNING – SEPARATE ONLY IN A NON-HAZARDOUS AREA
g)	7.4.2 e) 7.4.2 e) 7.4.3 d)	WARNING – POTENTIAL ELECTROSTATIC CHARGING HAZARD – SEE INSTRUCTIONS
h)	18.4 b) 21.2 b) 21.3.b)	WARNING – LIVE PARTS BEHIND COVER – DO NOT CONTACT

29.14 Cells and batteries

In accordance with 23.11, where it is necessary for the user to replace cells or batteries contained within an enclosure, the relevant parameters to allow correct replacement shall be legibly and durably marked on or inside the enclosure. Either the cell or battery manufacturer's name and part number, or the electrochemical system, nominal voltage and rated capacity shall be included.

When replaceable battery packs are employed, the replaceable battery pack shall be marked on the outside of the battery pack with the following:

- manufacturer's name;
- manufacturer's type identification; and
- the words "Use only on …" followed by the type identification of the intended equipment.

When replaceable battery packs are employed, the Ex Equipment shall be marked with the words "Use only replaceable battery pack" followed by the manufacturer and the manufacturer's type identification of the replaceable battery pack.

29.15 Electric machines operated with a converter

Electric machines intended to be operated with a converter shall additionally be marked:

- "For Converter Operation";
- Speed range or frequency range over which the machine is intended to be operated;
- Minimum switching frequency for low-voltage 2-level converters;

  NOTE 1 Switching frequency is considered to be the pulse frequency or the carrier frequency of the converter.

  NOTE 2 Low voltage is typically ≤ 1 000 Vac.
- Type of torque application; for example, variable torque, constant torque, constant power; or alternatively the operational torque limits;
- If applicable – Type identification of specific converter intended;

- If applicable – Type of converter intended, e.g., Pulse width modulated (PWM), multi-level, etc.

29.16 Examples of marking[2]

Electrical equipment with Type of Protection flameproof enclosure “d” (EPL Mb) for use in mines susceptible to firedamp:

BEDELLE S.A

TYPE A B 5

Ex db I Mb

No. 325

ABC 02.1234

.....

.....

Ex Component, with Type of Protection flameproof enclosure “d” (EPL Gb) with intrinsically safe “ia” (EPL Ga) output circuit, for explosive gas atmospheres other than in mines susceptible to firedamp, gas of subdivision C, manufactured by H. RIDSTONE and Co. Ltd. Type KW 369:

Ex db [ia Ga] IIC Gb

DEF 02.0536 U

.....

.....

Equipment, utilizing types of protection increased safety “e” (EPL Gb) and pressurized enclosure “px” (EPL Gb), maximum surface temperature of 125 °C, for explosive gas atmospheres other than mines susceptible to firedamp, with gas of ignition temperature greater than 125 °C and with specific conditions of use indicated in the certificate.

H. ATHERINGTON Ltd

TYPE 250 JG 1

Ex eb pxb IIC 125 °C (T4) Gb

No. 56732

GHI 02.0076 X

.....

.....

Equipment, utilizing types of protection flameproof enclosure “d” (EPL Mb and Gb) and increased safety “e” (EPL Mb and Gb) for use in mines susceptible to firedamp and explosive gas atmospheres other than mines susceptible to firedamp with gas of subdivision B and ignition temperature greater than 200 °C.

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2 This information is given for the convenience of users of this document and does not constitute an endorsement by the IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

A.R. ACHUTZ A.G.

TYPE 5 CD

Ex db eb I Mb Ex db eb IIB T3 Gb

No. 5634

JKL 02.0521

.....

.....

Electrical equipment, utilizing Type of Protection increased safety “e” (EPL Gb) for use in explosive gas atmospheres other than mines susceptible to firedamp with gas of subdivision C and ignition temperature greater than 85 °C.

GS & Co A.G.

Ex eb IIC T6 Gb

No. 1847

HYD 04.0947

.....

.....

Electrical equipment with Type of Protection flameproof enclosure “d” (EPL Gb) for explosive gas atmospheres other than mines susceptible to firedamp on the basis of ammonia gas only.

WOKAITERT SARL

TYPE NT 3

Ex db (NH_3) Gb

No. 6549

MNO 02.3102

.....

.....

Electrical equipment with Type of Protection encapsulation “m” (EPL Da) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 120 °C.

ABC company

Type RST

Serial No. 123456

Ex ma IIIC T_{200}120 °C Da

N.A. 01.9999

.....

.....

Electrical equipment with Type of Protection "i" (EPL Da) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 120 °C.

ABC company

Type XYZ

Serial No. 123456

Ex ia IIIC T_{200}120 °C Da

N.A. 01.9999

.....

.....

Equipment with Type of Protection "p" (EPL Db) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 120 °C.

ABC company

Type KLM

Serial No. 123456

Ex pxb IIIC T120 °C Db

N.A. 01.9999

.....

.....

Equipment with Type of Protection "t" (EPL Db) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 225 °C and less than 320 °C when tested with a 150 mm dust layer.

ABC company

Type RST

Serial No. 987654

Ex tb IIIC T225 °C T_{150} 320 °C Db

N.A. 02.1111

.....

.....

Equipment with Type of Protection "t" (EPL Db) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 175 °C with an extended ambient temperature range of -40 °C to +120 °C.

ABC company

Type RST

Serial No. 987654

Ex tb IIIC T175 °C Db

-40 ºC ≤ T_{amb} ≤ 120 °C

N.A. 02.1111

.....

.....

Equipment with Type of Protection encapsulation “m” (EPL Ga) for explosive gas atmospheres of Group IIC with a maximum surface temperature of less than 135 °C and with Type of Protection encapsulation “m” (EPL Da) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 120 °C. A single certificate has been prepared.

ABC company
Type RST
Serial No. 123456
Ex ma IIC T4 Ga Ex ma IIIC T120 °C Da N.A. 01.9999
.....
.....

Electrical equipment with Type of Protection encapsulation “ma” (EPL Ga) for explosive gas atmospheres of Group IIC with a maximum surface temperature of less than 135 °C and with Type of Protection encapsulation “ma” (EPL Da) for explosive dust atmospheres containing conductive dusts of Group IIIC with a maximum surface temperature of less than 120 °C. Two independent Certificates have been prepared.

ABC company
Type RST
Serial No. 123456
Ex ma IIC T4 Ga
N.A. 01.1111
Ex ma IIIC T_{200}120 °C Da N.B. 01.9999
.....
.....

30 Instructions

30.1 General

The instructions prepared by the manufacturer shall include the following particulars as a minimum:

- a recapitulation of the information with which the equipment is marked, except for the serial number (see Clause 29), together with any appropriate additional information to facilitate maintenance (for example, address of the importer, repairer, etc.);
- instructions for safety addressing the following areas:
  - on-site assembling;
    - i) any specialized installation information for the user, such as a specific sequence of assembling;
    - ii) information about the mechanical assembling such as pipe connections;
  - installation and erection;
    - i) information, other than the general requirements given in IEC 60079-14;
    - ii) information about bonding, shield earthing or overvoltage protection;
    - iii) guidance for the selection of flameproof entry devices for termination compartments with reference pressure greater than 2 000 kPa for Group II or 1 333 kPa for Group I.

      NOTE Minimum requirements in IEC 60079-1 for flameproof entry devices assume a maximum reference pressure of 2 000 kPa for Group II and 1 333 kPa for Group I. Other devices are available with ratings greater than these minimum requirements.
  - adjustment and parameter setting;
    - i) information about heating devices;
  - putting into service – of the equipment / of the whole installation;

i) information about verifications / tests prior to the (first) use of the equipment as required by the Type of Protection(s) – together with the sequence of conducting such verifications / tests;

ii) detailed information about any special installation requirements for the Type of Protection(s) employed

– use and setting-up;

i) details which allow an informed decision to be made as to whether the equipment can be used safely in the intended area under the expected operating conditions;

ii) ratings such as electrical values, ambient temperatures and pressures, maximum surface temperatures and other limit values related to a designated use;

iii) information for the user, not just giving parameters, related to the need of special overload protecting devices for increased safety “e”’ motors or special requirements related to electrostatics;

– maintenance;

i) information, other than the general requirements given in IEC 60079-17;

ii) information such as cleaning, oil level check or recalibration requirements;

iii) requirements for the maintenance of the explosion protection;

iv) information about troubleshooting;

– repair;

i) information, other than the general requirements given in IEC 60079-19;

ii) information related to the fitting or removal of parts / components;

iii) information about spare parts;

iv) requirements for a documentation of such repairs;

v) information about needed verifications / tests for the restarting of the equipment;

– taking out of service and dismantling;

i) information about the securing of mechanical parts to prevent a restart or about electrical disconnecting;

- where applicable, Specific Conditions of Use according to 29.3 e);
  - this information should not be hidden in the text and should be placed within the instructions in a highlighted way, often as a special chapter;
  - For Ex Components, a Schedule of Limitations is used in place of Specific Conditions of Use, See 13.5;
- where applicable, any additional information for use, including information related to possible misuse, which experience has shown might occur;
- where necessary, training instructions for a safe use;
- where necessary, the essential characteristics of tools which may be used with the equipment; such as a special screwdriver for trimming
- a list of the standards, including the issue date, with which the equipment is declared to comply. The list of standards is not required if the certificate indicates the standards covered by the certificate and their issue dates, even if the certificate is not included as part of the instructions.

30.2 Cells and batteries

In accordance with 23.11, where it is necessary for the user to replace cells or batteries contained within an enclosure, the relevant parameters to allow correct replacement shall be included in the instructions, including either the manufacturer’s name and part number, or the electrochemical system, nominal voltage and rated capacity. When replacement of the batteries or cells is intended to be done only when an explosive atmosphere is not present, the instructions shall specify the procedure for battery or cell replacement.

In accordance with 23.12, where it is necessary for the user to replace a battery pack, the instructions shall include the relevant parameters to allow correct replacement per 29.14. When replacement of the battery pack is intended to be done only when an explosive atmosphere is not present, the instructions shall specify the procedure for battery pack replacement.

30.3 Electric machines

In addition to the information required according to 30.1, the following additional information shall be prepared for electric machines, as applicable:

- speed/torque curves for machines intended to be supplied by a converter;
- For motors in Type of Protection “e” that have been type tested with a converter, the rated motor current, Weighted Voltage Total Harmonic Distortion (WTHD), or pulse frequency and DC-Link voltage of the converter used for the type testing to allow the selection of a comparable converter.

NOTE This information is often presented in a table.

Table 19 – Example of type-test converter parameters

Speed	Minimum speed	Base speed	Maximum speed
Current	I_1	I_2	I_3
Voltage	U_1	U_2	U_3
Weighted Voltage Total Harmonic Distortion	$WTHD_1$	$WTHD_2$	$WTHD_3$
The weighted voltage total harmonic distortion can be replaced by pulse frequency and the DC-link voltage.			

- guidance for the selection and installation of any necessary overload protection or over-temperature protection of the motor, including guidance for recommended alarm and shutdown levels (including voting logic for multiple sensor inputs), if applicable, for winding and bearing temperature detection. This may be in addition to protection provided by a converter;
- bearing lubrication requirements for both commissioning and maintaining;
- the permitted axial and radial loading of the shaft;
- the thermal expansion of the shaft and the housing under the rated conditions;
- any necessary maintenance of the protection provided by the manufacturer against stray circulating currents in the bearings or shafts;

  NOTE Annex H provides additional information on stray circulating currents and shaft voltages.

- any necessary protection of the bearings from vibration, including during transportation, storage, or standby service;
- guidance on maintenance and replacement intervals for bearings based on the operating conditions.

30.4 Ventilating fans

In addition to the information required according to 30.1, the following additional information shall be prepared for ventilating fans according to 17.2.5:

a) Minimum and maximum air flow rates (with respect to surface temperature and temperature ratings);

b) Back pressure if required (to operate the fan within the ratings);

c) Any limitations with respect of the ingress of foreign particles (e.g. requirements for IP-protection, etc., for duct inlets according to 17.2.5.);

NOTE Fans intended for particularly adverse service conditions according to the notes of 6.1 e.g. fans for paint spray booths, require the manufacturer and user to agree on suitable additional measures (e.g. the use of filters for the inlet) to prevent deposits inside fan and ducts which can impair the explosion protection.

d) Any special earthing measures to be employed to avoid the build up of electrostatic charges.

30.5 Cable glands

See A.5 for the requirements for the additional information to be prepared for cable glands.

Annex A
(normative)

Supplementary requirements for cable glands

A.1 General

This annex specifies the additional requirements for the construction, testing and marking of cable glands and may be further supplemented or modified by the standards listed in Clause 1.

The requirements for cable glands also apply to cable transit devices.

The non-metallic parts of a cable gland are non-metallic parts of enclosures upon which the Type of Protection depends. See Clause 7.

NOTE 1 The minimum diameter of cable for which the cable gland is suitable is specified by the cable gland manufacturer. In accordance with IEC 60079-14, the user is expected to ensure that, taking tolerances into account, the minimum dimensions of the cable selected for use in the cable gland are equal to, or exceed, these specified values.

The requirements of Annex A apply also to cable transit devices which may be certified as either Ex Equipment or as an Ex Component. The cable transit device may only be certified as equipment provided that the device includes a flange gasket and the manufacturer's instructions state that the device shall be mounted in such a way that the joints between the flange and the enclosure fulfils the required degree of ingress protection after mounting. The particular gasket shall be included as part of the tests of A.3.4. The device certificate number shall include the suffix "X" to indicate this specific condition of use according to item e) of 29.3and this specific condition of use regarding ingress protection (IP) after mounting, shall be stated on the certificate. Depending on the form of construction and the resilience of the gasket, the condition or instructions may need to refer to the flatness or rigidity of the enclosure to which the gland is attached.

Metallic hose assemblies in accordance with ISO 10807 can be used to protect cables against damage. They are permitted to be part of a cable gland where they do not invalidate:

– the clamping of the cable gland;
– the sealing of the cable gland; and
– the fixing of the cable gland.

In all cases, the cable gland shall comply with the requirements of this standard without the metallic hose assemblies.

A.2 Constructional requirements

A.2.1 Cable sealing

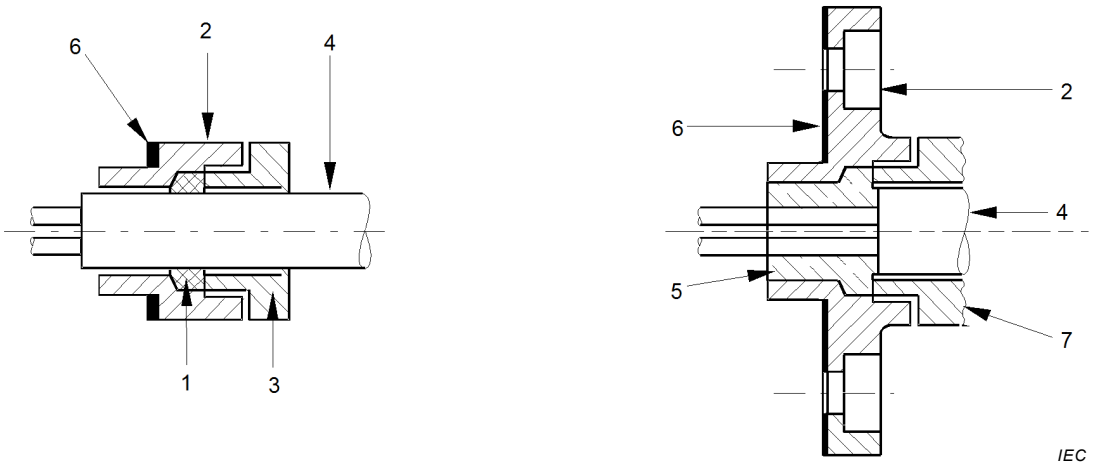
The ingress protection between the cable and the cable gland shall be ensured by one or more of the following means (see Figure A.1):

– an elastomeric sealing ring;
– a metallic or composite sealing ring;
– a filling compound;
– other suitable means.

The cable sealing may be made of a single material or a combination of materials and shall be appropriate to the shape of the cable concerned.

NOTE 1 In selecting the materials for sealing rings, attention is drawn to Note 2 of 6.1.

NOTE 2 The Type of Protection of the enclosure may also depend on the internal construction of the cable.



Components

1 sealing ring
2 gland body
3 compression element
4 cable
5 filling compound
6 gasket (where required)
7 compound retaining element

Figure A.1 – Illustration of the terms used for cable glands

A.2.2 Filling compounds

Materials used as filling compounds shall comply with the requirements of 7.1.2.4 for materials used for cementing.

A.2.3 Clamping

A.2.3.1 General

Cable glands shall provide clamping of the cable in order to prevent pulling applied to it from being transmitted to the connections. Such clamping can be provided by the cable sealing means (see A.2.1) or by an integral clamping device. It shall be capable of meeting the relevant type tests in Clause A.3.

A.2.3.2 Group II or III cable glands

Cable glands for Group II or III Ex Equipment, without a clamping device shall also be accepted as complying with this annex if they are capable of passing the clamping tests with values reduced to 25 % of those required in Clause A.3. Such cable glands shall be marked with the symbol “X” according to item e) of 29.3, and the Specific Condition of Use shall specify that the user shall provide additional clamping of the cable to ensure that pulling is not transmitted to the terminations.

A.2.4 Lead-in of cable

A.2.4.1 Sharp edges

Cable glands shall not have sharp edges capable of damaging the cable.

A.2.4.2 Point of entry

In the case of flexible cables, the point of entry shall include a rounded edge at an angle of at least 75°, the radius R of which is at least equal to one-quarter of the diameter of the maximum admissible cable in the entry but which need not exceed 3 mm (see Figure A.2).

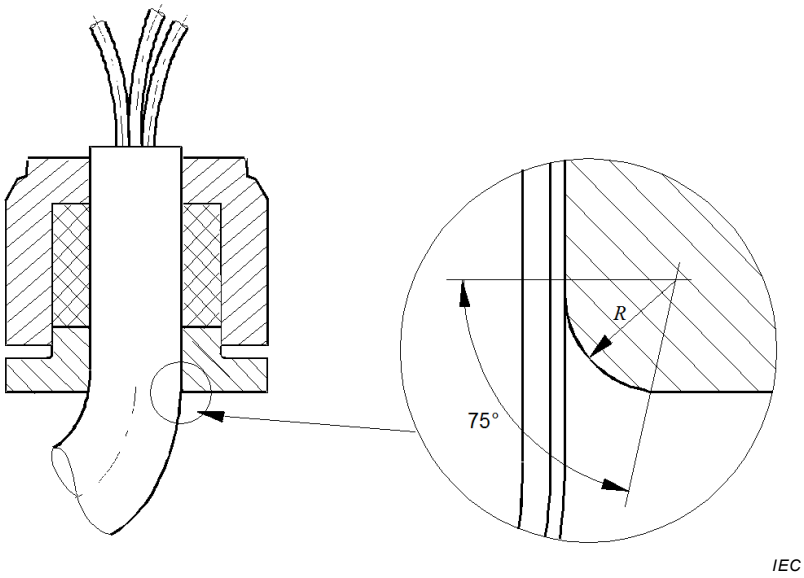


Figure A.2 – Rounded edge of the point of entry of the flexible cable

A.2.5 Release by a tool

Cable glands shall be designed so that after installation they are only capable of being released or dismantled by means of a tool.

A.2.6 Fixing

The means of fixing cable glands to enclosures of equipment shall be capable of retaining the cable gland when subjected to the mechanical tests of clamping and resistance to impact in Clause A.3.

A.2.7 Degree of protection

Cable glands, when installed in a test enclosure in accordance with the instructions required by A.5, shall be capable of providing the degree of protection (IP) in accordance with A.3.4.

A.3 Type tests

A.3.1 Tests of clamping of non-armoured and braided cables

A.3.1.1 Cable glands with clamping by the sealing ring

The tests of clamping shall be carried out using for each type and size of cable gland, two sealing rings; one equal to the smallest admissible size and the other equal to the largest admissible size.

For elastomer sealing rings for circular cables, each ring shall be mounted on a clean, dry, polished, cylindrical, stainless steel mandrel, with a maximum surface roughness of 1,6 μm, Ra, less than or equal to the smallest cable diameter allowable in each of the two rings, as specified by the manufacturer of the cable gland.

For elastomer sealing rings with multiple holes for sealing on individual cables or cores, the tests of clamping shall be carried out on the samples described using stainless steel mandrels with a maximum surface roughness of 1,6 μm, Ra, and with a diameter less than or equal to the smallest diameter allowable for the core diameter being tested. A sample for the maximum number of cores for the maximum core diameter permitted, and a sample for the maximum number of cores for the minimum core diameter permitted by the cable gland manufacturer.

NOTE Clarification of the test sample requirements for multiple hole sealing rings is under consideration.

For non-circular cables, the ring for each type/size/shape of cable shall be mounted on a sample of dry, clean cable of dimensions equal to the size specified by the manufacturer of the cable gland. Alternatively, a clean, dry, polished, stainless steel mandrel, with a maximum surface roughness of 1,6 μm, Ra, with dimensions less than or equal to the smallest cable dimensions allowable is permitted. For metallic-sheathed cables, the ring for each size of cable shall be mounted on a sample of dry, clean cable constructed with the sheath material and with dimensions less than or equal to the size as specified by the manufacturer of the cable gland.

For metallic sealing rings, each ring shall be mounted on a clean, dry, polished, cylindrical, stainless steel mandrel, with a maximum surface roughness of 1,6 μm, Ra, less than or equal to the smallest cable diameter allowable in the ring and specified by the manufacturer of the cable gland.

As an alternative to the mandrel, a sample of clean, dry cable of an equivalent size, and as specified by the manufacturer of the cable gland, may be used. It should be noted that this cable is now a non-metallic material on which the Type of Protection depends, and is subject to the requirements of 7.1.1.

The sealing ring with the mandrel or the cable, as appropriate, shall be fitted into the cable gland. A torque shall then be applied to the screws (in the case of a flanged compression element fitted with screws) or to the nut (in the case of a screwed compression element) to compress the sealing ring to secure the mandrel or cable.

The sealing ring shall secure the cable or mandrel when the force applied to the cable or mandrel, in Newtons, is equal to:

– 20 times the value in millimetres of the diameter of the mandrel or cable when the cable gland is designed for round cable, or
– 6 times the value in millimetres of the perimeter of the cable when the cable gland is designed for non-circular cable.

Where the direction of force is other than horizontal, the means of application of the force shall be adjusted to compensate for the weight of the mandrel and associated parts. The direction of the applied force shall be outward from the gland attachment.

NOTE Clarification of the securing tests for multiple hole sealing rings is under consideration. For cable glands intended for use with braided cables, this clamping test is intended to demonstrate the effectiveness of the cable gland in clamping the cable, not the strength of the braid. Where the test is performed with braided cable, the braid shall not be clamped.

The force shall be applied for not less than 1 h. The test shall be carried out at an ambient temperature of (20 ± 5) °C. The clamping assured by the sealing ring shall be acceptable if the slippage of the mandrel or cable sample is not more than 2 mm. Either the complete cable gland and mandrel assembly tested above, or a new sample prepared using the same torque values, shall then be subjected to the thermal endurance tests (26.8 and 26.9), if applicable. The maximum service temperature shall be considered to be 75 °C unless otherwise specified by the manufacturer.

The torque figures referred to above may be determined experimentally prior to the tests or they may be supplied by the manufacturer of the cable gland.

NOTE 1 Cable glands tested against earlier editions of this standard were tested for 6 h with slippage of not greater than 6 mm, after thermal endurance. Those results are still considered suitable as the basis for the tests of A.3.1.4

NOTE 2 The 75 °C service temperature is the median of the branching point and entry point temperatures.

NOTE 3 Cable glands employing only metallic sealing rings and metallic parts do not require thermal endurance tests.

The subsequent test conditions and acceptance criteria are given in A.3.1.4.

A.3.1.2 Cable glands with clamping by filling compound

The tests of clamping shall be carried out using samples prepared with stainless steel mandrels, one with a single mandrel with a diameter greater than or equal to the maximum diameter over cores, and the other with the maximum number of mandrels representing the maximum number of cores specified by the cable gland manufacturer.

NOTE 1 The diameter over cores represents the diameter of the core bundle.

The available space shall be filled with the filling compound, which has been prepared and hardened in accordance with the manufacturer of the cable gland's instructions prior to being submitted to the tests.

The complete cable gland and mandrel assembly shall then be subjected to the thermal endurance tests. The maximum service temperature shall be considered to be 75 °C unless otherwise specified by the manufacturer.

NOTE 2 The 75 °C service temperature is the median of the branching point and entry point temperatures.

The filling compound shall prevent slippage of the mandrel when the force applied, in Newtons, is equal to:

– 20 times the value in millimetres of the diameter of the intended cable when the cable gland is designed for circular cable, or
– 6 times the value in millimetres of the perimeter of the intended cable when the cable gland is designed for non-circular cable.

Where the direction of force is other than horizontal, the means of application of the force shall be adjusted to compensate for the weight of the mandrel and associated parts. The direction of the applied force shall be outward from the gland attachment.

For cable glands intended for use with braided cables, this clamping test is intended to demonstrate the effectiveness of the cable gland in clamping the cable, not the strength of the braid. Where the design of the cable gland is such that the braid is intended to be surrounded by compound, the contact of the compound with the braid shall be minimized for this test.

The test conditions and acceptance criteria are given in A.3.1.4.

A.3.1.3 Cable glands with clamping by means of a clamping device

The clamping test shall be carried out on each type and size of cable gland clamping device.

The clamping device shall be mounted on a stainless steel mandrel or on a sample of clean, dry cable of a size allowable in the device as specified by the manufacturer of the cable gland.

The clamping device with any required sealing ring and the largest size of cable allowable in that clamping device, as specified by the manufacturer of the cable gland, shall be fitted in the cable gland. The gland shall be assembled with compression of any required sealing ring and tightening of the clamping device. The test procedure shall be carried out in accordance with

A.3.1.1 and then repeated with the smallest size of mandrel or cable allowable in that clamping device, as specified by the manufacturer of the cable gland.

For cable glands intended for use with braided cables, this clamping test is intended to demonstrate the effectiveness of the cable gland in clamping the cable, not the strength of the braid. Where the test is performed with braided cable, the braid shall not be clamped.

A.3.1.4 Clamping test

The test sample, as prepared in A.3.1.1 to A.3.1.3, as appropriate, shall be subjected to a constant force equal to that given in A.3.1.1 or A.3.1.2, as appropriate. Prior to the application of the specified force, the gland may be re-tightened in accordance with the manufacturer's instructions. The load shall be applied for not less than 6 h. The test shall be carried out at an ambient temperature of (20 ± 5) °C. The clamping assured by the sealing ring, filling compound or by the clamping device shall be acceptable if the slippage of the mandrel or cable sample is not more than 6 mm.

NOTE The torque applied to the screws or nut during retightening is not required to be the same as the initial torque applied in A.3.1.1.

A.3.1.5 Mechanical strength

After the clamping tests have been completed, the cable gland shall be submitted to the tests and examinations of a) to c) as appropriate.

a) For cable glands with clamping by sealing ring or a clamping device, a mechanical strength test on which a torque of at least 1,5 times the torque required for A.3.1.4 shall be applied to the screws or nuts (whichever is the case). The cable gland shall then be dismantled and the components examined. The mechanical strength of the cable gland shall be acceptable if no deformation affecting the Type of Protection is found. Any deformation of the sealing rings shall be ignored.

b) For cable glands manufactured from non-metallic materials, it is possible that the prescribed proof torque cannot be met due to temporary deformations of the thread. If no noticeable damage is found, the cable gland shall be deemed to have passed the test if the clamping test of A.3.1.4 can still be achieved without adjustment.

c) For cable glands with clamping by filling compound, the gland shall be dismantled as far as possible without damaging the filling compound. Upon examination, there shall be no physical or visible damage to the filling compound that would affect the Type of Protection afforded.

A.3.2 Tests of clamping of armoured cables

A.3.2.1 Tests of clamping where the armourings are clamped by a device integral to the gland

A.3.2.1.1 General

The tests shall be carried out using a sample of armoured cable of the smallest size specified for each type and size of gland. Armouring dimensionally equivalent to the cable may be used for the test. The sample of armoured cable shall be fitted into the clamping device of the cable gland. A torque shall then be applied to the screws (in the case of a flanged clamping device) or to the nut (in the case of a screwed clamping device) in order to compress the clamping device and prevent slipping of the armour. The torque so determined shall be used as a reference torque.

The clamping device shall prevent slippage of the armour when the force applied to the armour, in Newtons, is equal to:

- 80 times the value in millimetres of the diameter of the cable over the armour for Group I equipment, or

- 20 times the value in millimetres of the diameter of the cable over the armour for Group II or III equipment.

NOTE 1 The torque values referred to above are often determined experimentally prior to the clamping tests, or they may be supplied by the manufacturer of the cable gland.

Where the direction of force is other than horizontal, the means of application of the force shall be adjusted to compensate for the weight of the mandrel and associated parts. The direction of the applied force shall be outward from the gland attachment.

The complete cable gland and armoured cable shall then be subjected to the thermal endurance tests. The maximum service temperature shall be considered to be 75 °C unless otherwise specified by the manufacturer.

NOTE 2 The 75 °C service temperature is the median of the branching point and entry point temperatures.

NOTE 3 Cable glands employing only metallic sealing rings and metallic parts do not require thermal endurance tests.

A.3.2.1.2 Clamping test

The test sample shall be subjected to a constant force equal to that defined in A.3.2.1 shall be applied for (120 ± 10) s. The test shall be carried out at an ambient temperature of (20 ± 5) °C. The clamping assured by the clamping device shall be acceptable if the slipping of the armour is effectively negligible.

A.3.2.1.3 Mechanical strength

Where screws and nuts are fitted they shall be tightened to at least 1,5 times the reference torque values established in A.3.2.1.2 and then the cable gland dismantled. The mechanical strength shall be acceptable if no deformation affecting the Type of Protection is found.

A.3.2.2 Tests of clamping where the armourings are not clamped by a device integral to the gland

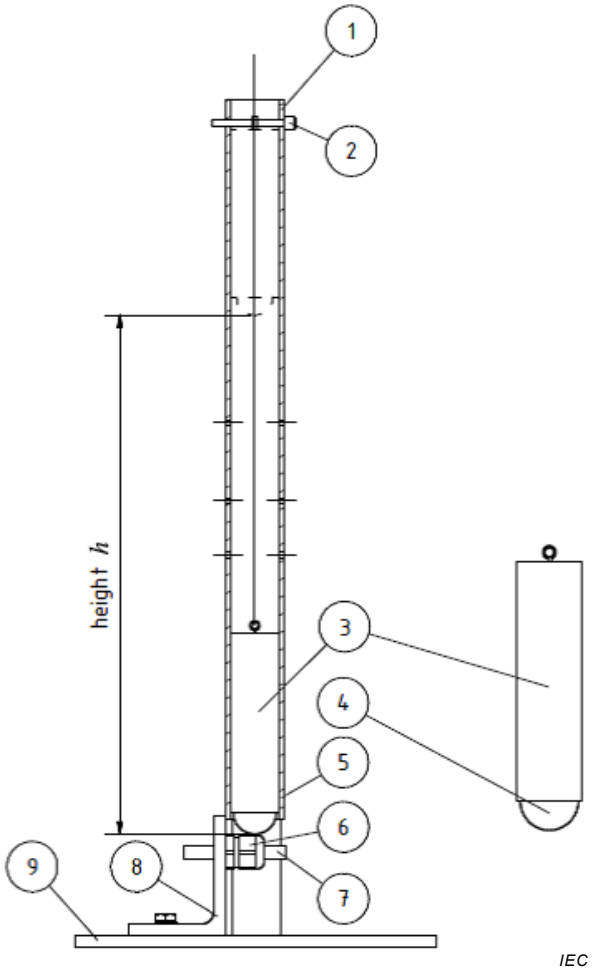
The cable gland shall be treated as if it were a non-armoured type according to A.3.1.

A.3.3 Type test for resistance to impact

For the tests of 26.4.2, each type and size of cable gland shall be tested with the smallest mandrel or smallest cable size fitted.

For testing purposes, the cable gland shall be fixed on a rigidly mounted steel plate or secured as specified by the manufacturer of the cable gland. The torque applied in fixing a threaded cable gland shall be that used to assemble the samples for the clamping test in A.3.1.4 or A.3.2.1.2, as applicable.

See Figure A.3 for an example of a rig for resistance to impact test.



Components

1	guide tube	6	cable gland
2	release pin	7	test cable
3	steel mass of 1 kg	8	mounting angle
4	impact head of hardened steel, 25 mm in diameter	9	steel base (mass ≥20 kg)
5	guide tube	*h*	height of fall

Figure A.3 – Example of rig for resistance to impact test

A.3.4 Test for degree of protection (IP) of cable glands

Prior to the IP tests, the test samples shall be subjected to the thermal endurance tests (26.8 and 26.9) and resistance to impact (A.3.3) tests (if applicable). The test shall then be carried out in accordance with IEC 60529 as below, using one cable-sealing ring of each of the different permitted sizes for each type of cable gland.

Group I – IP54 minimum

Group II – IP54 minimum

Group III, EPL Da – IP6X minimum

Group III, EPL Db – IP6X minimum

Group IIIC, EPL Dc – IP6X minimum

Group IIIA or IIIB, EPL Dc – IP5X minimum

For sealing tests, each sealing ring shall be mounted on a sample of clean, dry cable; or a clean, dry, polished, stainless steel mandrel, with a maximum surface roughness of 1,6 μm Ra, of a diameter equal to the smallest diameter allowable in the ring as specified by the manufacturer of the cable gland. For the purposes of this test, the cable gland with cable or mandrel shall be tested after being fixed to a suitable test enclosure ensuring that the sealing method at the interface between the gland and enclosure is in accordance with A.5.

These test samples need not be the same test samples subjected to the tensile tests A.3.1.4 and mechanical strength tests A.3.1.5.

A.4 Marking

A.4.1 Marking of cable glands

Cable glands shall be marked in accordance with 29.3 and, unless specified otherwise by the manufacturer of the cable gland, shall include the marking for Level of Protection “eb” in addition to the marking for any other relevant Type of Protection; and, if a threaded entry, with the type and size of thread.

NOTE 1 Cable glands in Level of Protection “eb” are suitable for:

– all applications requiring EPL Gb or Gc, except for Type of Protection “d”,

– all applications requiring Level of Protection “ia”.

See IEC 60079-14.

NOTE 2 The additional requirements for cable glands of Type of Protection “d” are found in IEC 60079-1.

NOTE 3 The additional requirements for cable glands of Type of Protection “t” are found in IEC 60079-31.

NOTE 4 The minimum IP requirements vary by equipment Group. See A.3.4

Where marking space is limited, the reduced marking requirements of 29.11 or 29.12 may be applied.

A.4.2 Identification of cable-sealing rings

The cable-sealing rings for cable glands that allow a variety of ring sizes shall be identified such that the minimum and maximum diameters, in millimetres, of the permitted cables can be determined.

When the cable-sealing ring is bound with a metal washer, the identification may be made on the washer.

The cable-sealing rings shall be identified allowing the user to determine if the ring is appropriate for the cable gland.

Where the gland and the ring are intended to be used at temperatures outside the range −20 °C to +75 °C, they shall be marked with the temperature range.

NOTE The specific details of identification for sealing rings and temperature ranges is detailed in the instructions.

A.5 Instructions

In addition to the requirements for instructions given in 30.1, the instructions prepared for cable glands shall include at least the following:

a) minimum and maximum diameter of the cable of circular cables;

b) minimum and maximum dimensions of non-circular and metal-sheathed cables;

c) tightening process of the compression element, including the tightening torque;

d) for compound-filled glands, details on the installation of the filling compound;

e) for compound-filled glands, the maximum diameter over cores of the cable that the gland is intended to accept; and the maximum numbers of cores that can pass through the compound;

f) for entries into enclosures:

- threaded entries:
  - thread size and tolerance class;
  - enclosure material limitations;
  - enclosure interface sealing method;
  - maximum surface roughness of the enclosure face for sealing;
  - thickness range of the enclosure wall;
  - perpendicularity;
  - permitted use and location of any earth tags;
- clearance holes:
  - hole dimensions, including tolerance;
  - enclosure material limitations;
  - thickness range of the enclosure wall;
  - enclosure interface sealing method;
  - maximum surface roughness of the enclosure face for sealing;
  - perpendicularity;
  - cable gland securing details;
  - permitted use and location of any earth tags.

NOTE For an enclosure with a wall including draft, a spot-face of the outer surface is a common way to allow the cable gland and sealing ring to be installed perpendicular to the enclosure wall.

Annex B
(normative)

Requirements for Ex Components

Ex Components shall comply with the requirements of the relevant clauses listed in Table B.1.

Table B.1 – Applicability of clauses to Ex Components

Clause or sub-clause	Applies (yes or no)	Remarks
1 to 4 (inclusive)	Yes	
5	No	Except that the service temperature limits shall be specified
6.1	Yes	
6.2	No	
6.3	No	
6.4	No	
6.5	Yes	
6.6	Yes	
7.1	Yes	See [a]
7.2	Yes	See [a]
7.3	Yes	See [a]
7.4	Yes	If external, See [a]
7.5	Yes	If external, See [a]
8	Yes	
9.1	Yes	
9.2	Yes	But only if it is an equipment enclosure
9.3	Yes	But only if it is an equipment enclosure
9.4	Yes	But only if it is an equipment enclosure
10	Yes	
11	Yes	
12	No	
13	Yes	
14	Yes	
15.1.1	Yes	But only if it is an equipment enclosure
15.1.2	Yes	But only if it is an equipment enclosure
15.2	Yes	
15.3	Yes	
15.4	Yes	But only if it is an equipment enclosure
15.5	Yes	But only for an earthing or bonding connection
15.6	Yes	
15.7	Yes	But only if it is an equipment enclosure
16	Yes	But only if it is an equipment enclosure
17.1	Yes	
17.2	No	Except for machine enclosures
17.3	Yes	
18	Yes	
19	No	

Clause or sub-clause	Applies (yes or no)	Remarks
20	Yes	
21	Yes	
22.1	Yes	
22.2	No	
23	Yes	
24	Yes	
25	Yes	
26.1	Yes	
26.2	No	
26.3	Yes	
26.4	Yes	But only if it is an equipment enclosure
26.5	Yes	
26.5.1	Yes	Where necessary to define a service temperature
26.5.2	Yes	
26.5.3	Yes	Where the “small component” relaxation has been employed
26.6	Yes	
26.7	Yes	Where the maximum temperature is specified
26.8	Yes	
26.9	Yes	
26.10	Yes	But only if it is an equipment enclosure
26.11	Yes	But only if it is a Group I equipment enclosure
26.12	Yes	But only if it is an equipment enclosure
26.13	Yes	But only if it is an equipment enclosure
26.14	Yes	But only if it is an equipment enclosure
26.15	No	
26.16	Yes	But only if it is an equipment enclosure
26.17	Yes	But only if it is an equipment enclosure
27	Yes	
28	Yes	
29.1	Yes	
29.2	Yes	Marking is required on the Ex Component
29.3	No	
29.4	Yes	See [b]
29.5	Yes	See [b]
29.6	Yes	
29.7	No	
29.8	Yes	
29.9	Yes	
29.10	Yes	
29.11	Yes	
29.12	Yes	
29.13	No	
29.14	Yes	
29.15	No	
29.16	No	

Clause or sub-clause	Applies (yes or no)	Remarks
30	No	Information necessary to correctly apply the Ex Component shall be included in the Schedule of Limitations on the Certificate. Additional information may be prepared as instructions for the incorporation of the Ex Component in the final assembly of Ex Equipment.

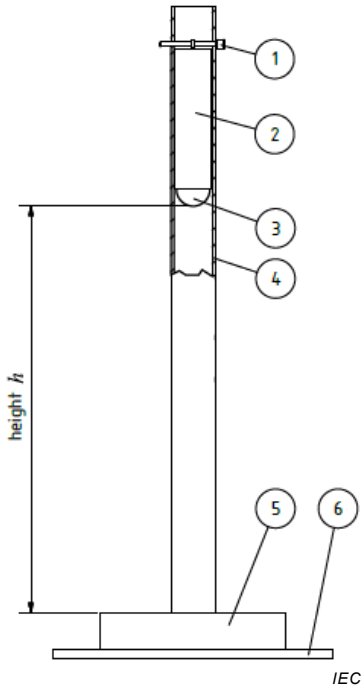
[a] It is necessary to consider the circumstances in which these requirements apply to components placed in other enclosures.

[b] The temperature classification is not applied to Ex Components.

Annex C
(informative)

Example of rig for resistance to impact test

See Figure C.1 for an example of a rig for resistance to impact test.



Components

1	release pin	5	test piece
2	steel mass of 1 kg	6	steel base (mass ≥20 kg)
3	impact head of hardened steel, 25 mm in diameter	*h*	height of fall
4	guide tube		

Figure C.1 – Example of rig for resistance to impact test

Annex D
(informative)

Electric machines connected to converters

When motors are connected to a converter to enable operation at varying speeds and loads, it is necessary to establish the thermal performance with a converter (and output filter, if used) throughout the specified speed and torque range. This needs to be done through a combination of type testing and calculation. The specific methods to be used are described in the specific standards for the Type of Protection.

NOTE 1 Because of possible difficulties in arranging a test with the exact electric machine/converter combination, tests using a comparable converter are often conducted, subject to comparison of the characteristics.

NOTE 2 Additional factors are typically taken into account, in discussion between manufacturer, user and installer. These include the provision by the user of additional output filters, or reactors, and the length of cable between converter and the electric machine, which both affect input voltage and can cause additional heating.

For some types of protection, it will be necessary to use sensors along with a safety device to limit temperatures. The requirements for the safety device need to be specified in the documentation in accordance with Clause 24 and in the instructions in accordance with Clause 30. Its effectiveness needs to be proven by test or by calculation.

NOTE 3 High-frequency switching in converters can lead to rapid rise time voltage stress in the windings and cable circuits and therefore a further potential source of ignition. The deleterious effects of this stress will vary according to the Type of Protection. In some circumstances, an additional output filter after the converter can help to reduce the rapid rise time voltage stress in the windings and cable circuit.

The documentation in accordance with Clause 24 and the instructions in accordance with Clause 30 need to include the necessary parameters and conditions required for use with a converter.

Stray currents may be introduced into shafts and bearings in electric machines connected to converters. One or more of the following solutions should be employed:

- use of suitable filters between the electric machine and the converter;
- use of shaft earthing or bonding brushes with a Type of Protection suitable for the intended EPL;
- use of bearing and shaft coupling insulation techniques;
- bonding and earthing cabling and potential equalizing systems;
- symmetrically configured low-voltage cables, with respect to the cable’s phase and earthing conductors, for supply conductors between the converter and the electric machine;
- suitable converter topology matched with the electric machine design to minimize common mode voltages.

Alternative methods may be employed which can demonstrate the elimination of common mode voltages.

NOTE 4 Further information is given in IEC TS 60034-25 and IEEE/PCIC-2002-08.

NOTE 5 These stray currents can also be introduced into other parts of the mechanical system.

NOTE 6 The electro-magnetic radiation from cables of electric machines connected to a converter may be sufficient to cause interference with proper operation of Group I pilot wire circuits.

Annex E
(informative)

Temperature evaluation of electric machines

Although this Annex is written in the context of motors, a similar approach may be applied for generators using the concepts of this Annex.

NOTE 1 IEC 60079-14 requires that all motors be installed with an overload protective device to provide protection against overloads and other expected malfunctions. There are some Levels of Protection, such as “eb” that typically require an additional Ex safety device to limit the maximum surface temperatures to within the marked temperature class. In some cases, the overload protective device and the Ex safety device are combined into a single unit. The temperature rise testing of electric machines described in this standard is not conducted with an overload protective device connected.

NOTE 2 National regulations, such as ATEX Directive 2014/34/EU, require that consideration be given to the performance of safety devices required for or contributing to the safe functioning of equipment with respect to risk of explosions.

Typical expected malfunctions for electric motors, as indicated in IEC 60034-11, include the following. The requirements for individual Types of Protection may not include all of the following expected malfunctions.

- Thermal overload with slow variation as a result of:
  - defects in ventilation or the ventilation system due to excessive dust in the ventilation ducts, or dirt on windings or frame cooling ribs; etc.
  - excessive rise in ambient temperature or the temperature of the cooling medium;
  - gradual increasing mechanical overload;
  - excessive duty on a motor rated for intermittent duty;
  - prolonged voltage drop, overvoltage, or unbalance in the machine supply;
  - frequency deviations.
- Thermal overload with rapid variation as a result of:
  - stalling the motor;
  - phase failure;
  - starting under abnormal conditions, for example, high inertia, voltage too low, load torque abnormally high;
  - sudden and significant increase in load;
  - starting repeatedly during a short time.

The maximum tolerance on the rated voltage (positive or negative) will result in the maximum surface temperature occurring on either the stator or the rotor. Typically, it depends on the following conditions:

- Small asynchronous motors rated at less than approximately 5 kW, generally exhibit the maximum surface temperature when operating with an applied voltage that is greater than the rated voltage, due to the core loss and magnetizing current, which increases rapidly as the iron core saturates at the higher applied voltage.
- Asynchronous motors rated generally between 5 kW and 20 kW are influenced by many factors that determine the performance and it is not possible to predict the overriding effect without detailed knowledge of the particular design.
- Larger asynchronous motors rated at more than approximately 20 kW, generally exhibit the maximum surface temperature when operating with an applied voltage that is less than the rated voltage, due to the increased I2R losses resulting from the increased currents. In this case, these losses are generally greater than those that would occur from core losses and magnetizing current resulting from an applied voltage that is greater than the rated voltage.

NOTE 3 The rated powers shown are general reference values, depending on the relative core magnetizing.

The alternative temperature determination methods detailed in IEC 60034-29 may be applied. The “±5 %” or “±10 %” supply factors of 26.5.1 should be included in the determination of maximum surface temperature when the methods of IEC 60034-29 are applied.

The maximum surface temperature rise of converter connected motors should be determined under “worst case” conditions using one of the test methods below:

- Specific converter.
  - A motor should be tested with the intended converter.

    The normal ± 10 % variation of the input voltage need not be applied provided the output voltage of the converter, and the harmonic content of the output voltage waveform is effectively independent of a ± 10 % variation of the input voltage while maintaining the rated motor input current (speed dependent) and the volts/Hz ratio.

    NOTE 4 When an increase in converter input voltage leads to a change in the harmonic spectrum of the output (even if the nominal sinusoidal equivalent of the output voltage remains constant), this leads to increased losses due to harmonic effects and additional saturation losses in the motor iron.
- Comparable converter.
  - A motor may be tested using a comparable converter when sufficient information is available to judge the comparability. Additional safety factors are typically applied as appropriate to account for the degree of comparability.
  - The normal ± 10 % variation of the input voltage need not be applied provided the output voltage of the converter, and the harmonic content of the output voltage waveform is effectively independent of a ± 10 % variation of the input voltage while maintaining the rated motor input current (speed dependent) and the volts/Hz ratio.

    NOTE 5 output (even if the nominal sinusoidal equivalent of the output voltage remains constant), this leads to increased losses due to harmonic effects and additional saturation losses in the motor iron.
- Sinusoidal supply.
  - A motor need not be tested using a comparable converter, and may be tested using a sinusoidal supply under all of the following conditions:

    The intended load torque should be generally proportional to the square of the speed.

    The motor should be loaded to maximum load at maximum rated speed.

    The motor speed range is within 40 % to 100 % of maximum rated speed.

    An additional safety factor should be applied to account for the additional losses that occur when operated from a converter. The safety factor applied is 15 % on temperature rise in K unless calculations can demonstrate an alternative safety factor.
- Motors of Type of Protection “d”, “p[3]”, or “t” tested on sinusoidal supply
  - Provision of appropriate direct thermal protection sensors, normally in the stator winding, which have sufficient margin to be able to detect and prevent excessive temperatures at the rotor bearings, bearing caps, and shaft extensions. The margin may be determined by test or by calculation. The mandatory connection and use of the sensors, along with a safety device, is shown as a Specific Condition of Use.

When agreeable to the manufacturer, the user, and the certification body (if one is involved), calculations or alternative tests, with appropriate safety factors, may be used to determine the maximum surface temperature. Calculations should be based on previously established representative test data and in accordance to IEC TS 60034-25.

For the determination of the maximum surface temperature, the “worst case” condition of the converter connected motor needs to be determined, and might include the following:

---

3 Level of protection “pxb” might require a mandatory “cool down” time to allow hot internal components to cool to the marked temperature class.

- Torque/speed characteristics (Variable (square law) / linear / constant torque vs. speed):
  - Motors for Variable torque loads require maximum surface temperature determination at maximum power at maximum rated speed.
  - Motors for linear loads and constant torque loads require maximum surface temperature determination at least at the minimum and maximum speed.
  - Motors for complex loads require maximum surface temperature determination at least at the break points in the speed/torque curve.
- Constant power:
  - Require determination maximum surface temperature at minimum and maximum speed.
- Voltage drop (cable length, filters, converter):
  - The voltage drop of all components have to be taken into account during project planning and commissioning. Therefore, information about the voltage drop of converter, filter, voltage drop along the cable, system configuration and input voltage for converter will need to be known. The manufacturer's instructions in accordance with Clause 30 should provide the relevant information necessary to calculate / set up the range of operation.
- Output characteristics of the converter (dV/dt, switching frequency):
  - Lower switching frequencies tend to increase motor temperatures. Specific conditions of use may be required to specify the minimum switching frequency.
  - Multi-level (three or higher) converters generally result in reduced motor heating.
- Coolant:
  - Maximum surface temperature determined with minimum rated flow / maximum rated coolant temperature.
  - Specific conditions of use may be required to specify coolant requirements.

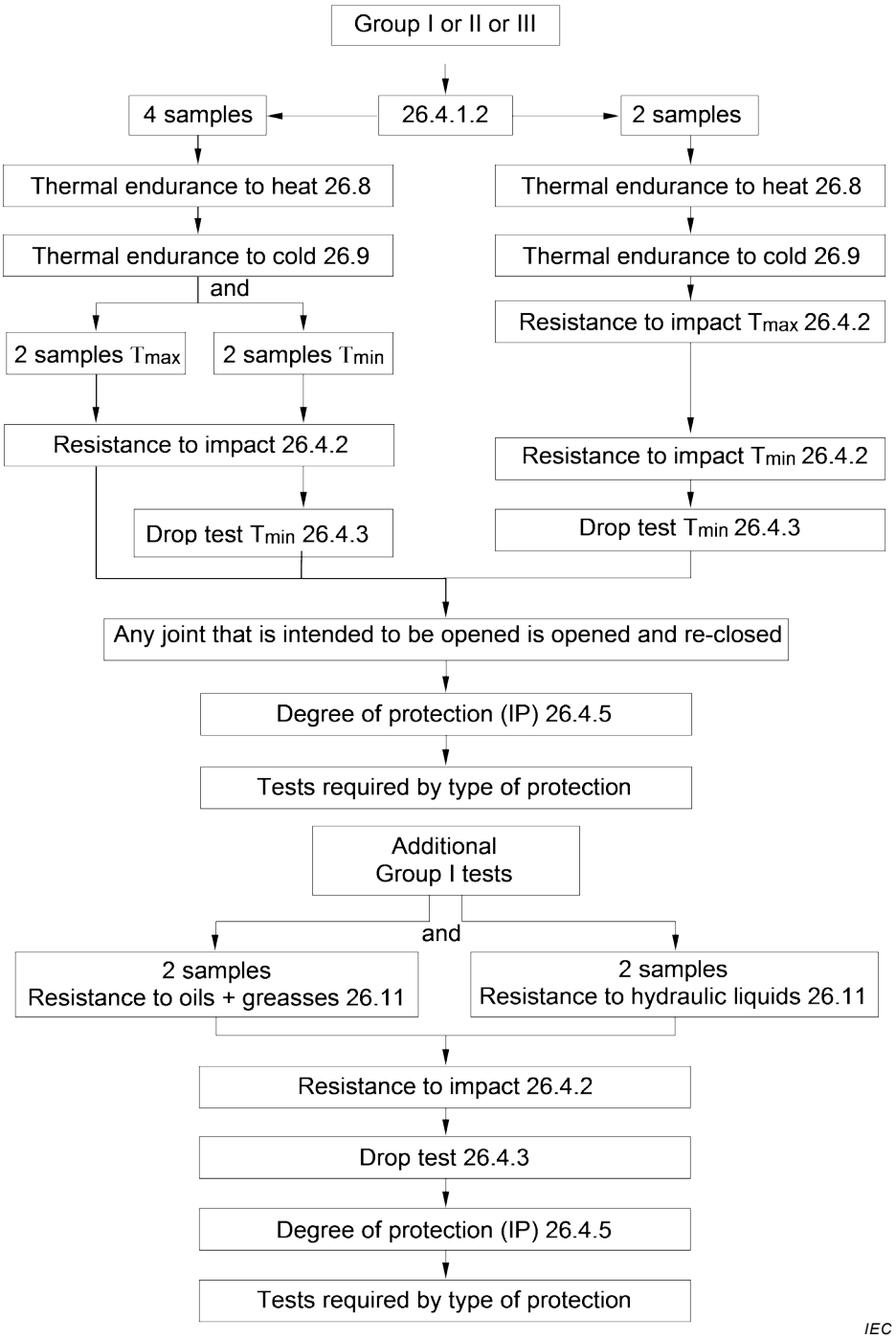
NOTE 6 The rotor can run significantly hotter than the stator. The significance of the problem varies with the Type of Protection. The determination of rotor temperature is particularly important for motors protected using levels of protection "ec", "eb", or some "pxb[3]" but are also significant for levels of protection "db", "pyb", "pzc", "tb", and "tc" when the hot rotor results in those high temperatures being transferred to the bearings, external shaft, and seals.

NOTE 7 Switching, pulse and carrier frequencies are considered to have the same meaning.

Annex F
(informative)

Guidance flowchart for tests of non-metallic enclosures or non-metallic parts of enclosures (26.4)

Figure F.1 provides a general overview of the tests of enclosures required for the most common implementations of equipment. Specific attention needs to be paid to the detailed text of the applicable requirements when developing the test program for specific equipment.

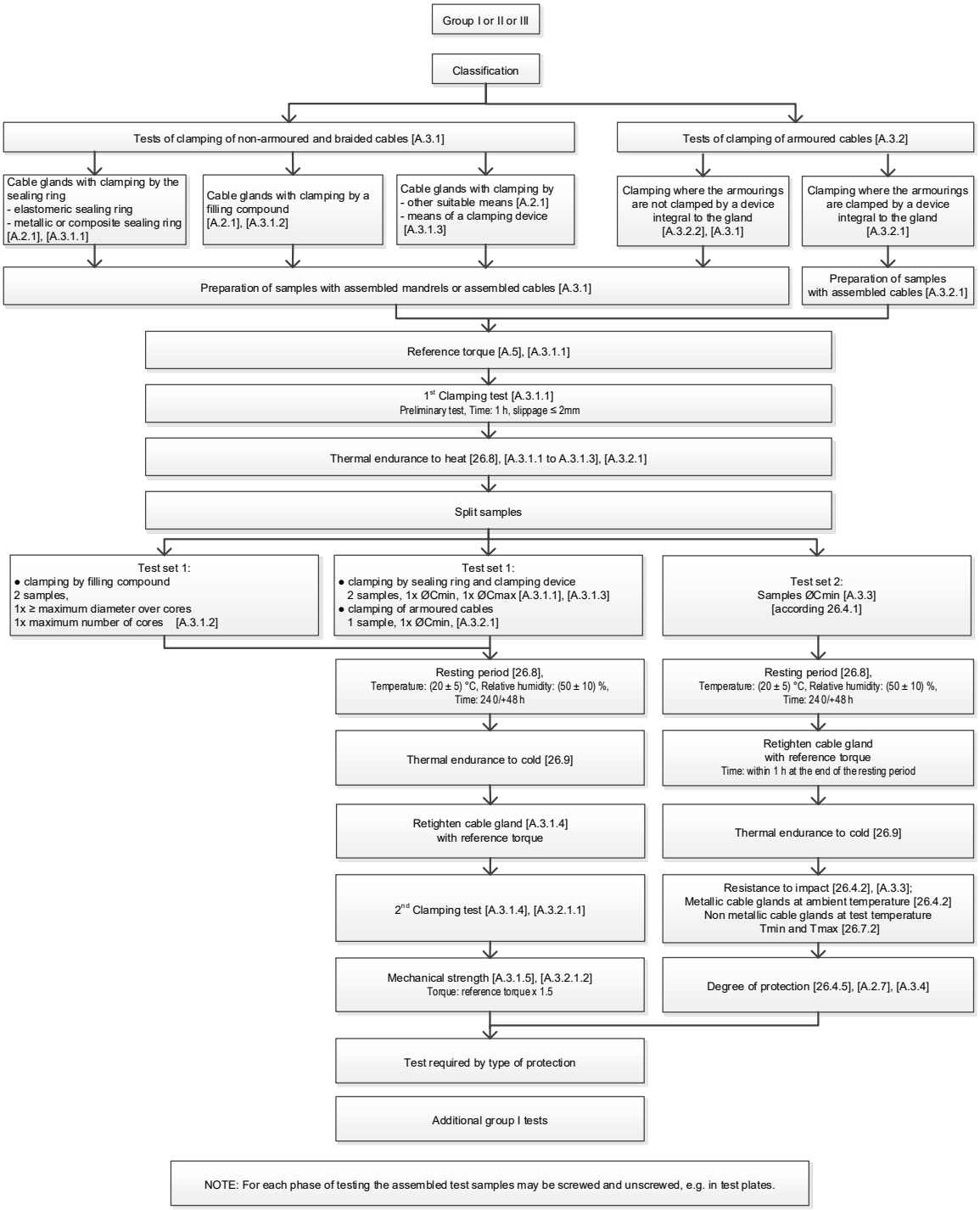


The order of the tests at T_{min} and T_{max} may be interchanged.

Figure F.1 – Non-metallic enclosures or non-metallic parts of enclosures

Annex G
(informative)

Guidance flowchart for tests of cable glands



Legend:

ØCmin – sealing ring equal to the smallest admissible size or smallest diameter for mandrel

ØCmax – sealing ring equal to the largest admissible size or largest diameter for mandrel

Tmax – maximal test temperature [26.7.2], [26.8]

Tmin – minimal test temperature [26.7.2], [26.9]

IEC

Annex H
(informative)

Shaft voltages resulting in motor bearing or shaft brush sparking Discharge energy calculation

H.1 General

A potential ignition source for larger machines and converter-fed motors of any size, can be bearing or shaft sparking due to common mode voltage (CMV) or circulating shaft currents. Voltage induced on or coupled to a machine shaft may result in a current with a magnitude limited by the impedance of the lubricating film in the bearing. The shaft voltage is typically considered as a voltage on a charged capacitor, with the capacitance provided by the rotor, stator and the bearings. When the shaft potential across the lubricating film reaches its dielectric breakdown voltage, a discharge occurs. The discharge can cause pitting in the bearing. Failure of the bearing can cause heating of the bearing.

A shaft bonding device that connects the machine shaft to the same potential as the frame of the machine close to the bearing, may be installed on the inside or outside of the machine to help extend the life of the bearings by essentially short-circuiting the capacitor, thus minimizing arcing at the bearing and prolonging bearing life.

Shaft bonding devices or bearings installed inside of a Type of Protection “d” or “p” machine or enclosure, do not present a source of ignition for a surrounding explosive atmosphere. Shaft bonding devices or bearings installed inside or outside of a Type of Protection “e” machine, or outside of a Type of Protection “d” or “p” machine, may present a risk of ignition which should then be mitigated. This Annex provides guidance on the suitability of shaft bonding devices not employing Type of Protection “d” or “p”.

H.2 Assessment of the risk of ignition using ignition energy calculation

The peak values of ignition energy can be measured, or they can be calculated when certain parameters are known. The resulting discharge energy can then be compared to the minimum ignition energy (MIE) of a specific flammable material or for an equipment Group as shown in Table H.1.

The capacitive discharge energy in the spark can be calculated using the following equation:

$$E = \frac{1}{2} CU^2 \tag{H.1}$$

Where:

E is maximum discharge energy (Joules);

C is total capacitance of the rotor and bearings across which voltage U appears (Farads); and

U is highest possible shaft peak voltage, including any transient effects (Volts).

The capacitance is based on the distributed area of the surfaces from the rotating assembly to grounded parts of the machine. These surfaces are typically between the rotor and stator and between the bearing surfaces at each end of the shaft. Each of those capacitance values is summed to form the overall capacitance value used to calculate the maximum discharge energy, E.

NOTE 1 For machines operated from a converter, U is conservatively estimated to be 10 % of the CMV of the converter. The shaft voltage can also be derived from the common-mode coupling effect between the winding/rotor capacitance to the rotor/frame capacitance..

Each contributing capacitor value can be determined using a suitable formula based on the geometry of the capacitor. For example, for a capacitor formed by concentric cylinders, either of the formulae below may be applied.

$$C = \frac{2\pi\varepsilon l}{ln\frac{b}{a}} \quad \text{(H.2)}$$

Where:

C is capacitance (farads);

$\varepsilon 0$ is permittivity of air (farads per metre);

ε is permittivity of the material other than air between the surfaces (farads per metre);

l is length of the cylinder (meters);

a^* is OD (metres); and

b^* is ID (metres).

* Inner Diameter (ID) and Outer Diameter (OD) dimensions of the parts of the motor for which C is being calculated such as the stator, rotor, shaft, end shield, bearing, etc. A radius is permitted if used for both parts in place of diameters.

NOTE 2 For air the permittivity is $8{,}85 \times 10^{-12}$. For oil or grease the permittivity is in the range of 18×10^{-12} to 25×10^{-12}.

The risk of ignition is effectively mitigated when the determined maximum discharge energy, E, is lower than the MIE of a specific flammable material or for the equipment Group as shown in Table H.1. For practical assessment of capacitance in individual cases, the curves shown in Figure H.4 should be used.

Table H.1 – Maximum permitted energy

Group I	Group IIA	Group IIB	Group IIC	Group III
0,2 mJ	0,2 mJ	0,06 mJ	0,02 mJ	0,2 mJ

H.3 Shaft voltage determination for a rotating machine

It is well documented that the output voltage of an inverter has a measurable common mode (CMV) component. CMV induces a shaft voltage on the inverter-fed machine. While the CMV tends to average out to zero over a specific period of time, the peak excursions which occur are of interest.

An oscilloscope and a probe for the electrical connection to the spinning motor shaft by means of a small conductive brush mounted are needed. The reference contact of the probe is connected to ground at the machine frame. The shaft voltages and current spikes caused by the pulsewidth-modulated output of motor drives can be exceedingly brief, often in the microsecond measurement range. The scope settings will need to take this into account.

H.4 Capacitance "*C*" calculation for a rotating machine

The capacitance, *C* is based on the distributed area of the surfaces from the rotating assembly to grounded parts of the motor. Insulation separating these metal parts is either air, such as in the rotor to stator gap, or lubricants such as oil or grease in the shaft bearings. Each contributing capacitor value can be determined using a suitable formula based upon the geometry of the portion of the rotating machine which is contributing the capacitance.

For a rotating machine, capacitance contributed between the following parts is possible:

1) inner bearing housing and the shaft;
2) outer bearing housing and the shaft;
3) shaft and the bearings for a machine having plane bearings;
4) bearing inner and out race in contact with each ball for ball bearings;
5) rotor and stator;
6) stator and frame.

The detailed geometry of the rotating machine would need to be obtained from the manufacturer in order to use appropriate dimensions for the equations.

Each contributing capacitive value can be determined with the formula for a cylindrical part as shown in Equation (H.2). A depiction of a sleeve bearing is shown in Figure H.1. A rotor to stator gap is shown in Figure H.2.

A representation of a ball bearing is shown in Figure H.3. For ball bearings, the total capacitance is the sum of the capacitance calculated for each individual section of the ball bearing as shown in Equation (H.2).

$$C_b = \frac{N_\mathrm{b} 4 \varepsilon_\mathrm{r} \varepsilon_0}{\frac{1}{R_\mathrm{b}} - \frac{1}{R_\mathrm{b} + R_\mathrm{c}}} \tag{H.3}$$

Where:

C_b = bearing capacitor in Farads

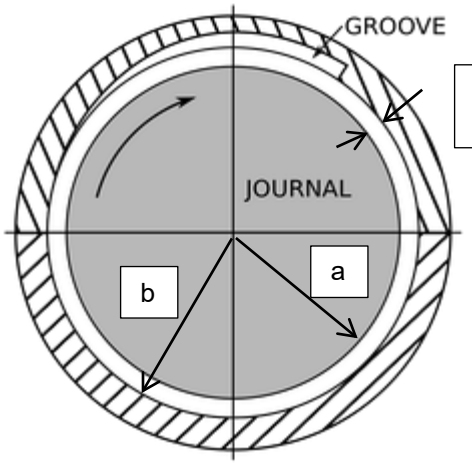
R_b = radius of bearing ball in metres

R_c = radial bearing clearance in metres

N_b = number balls

ε_0 = Permittivity of vacuum in farads/metres

ε_r = relative permittivity of the lubricant



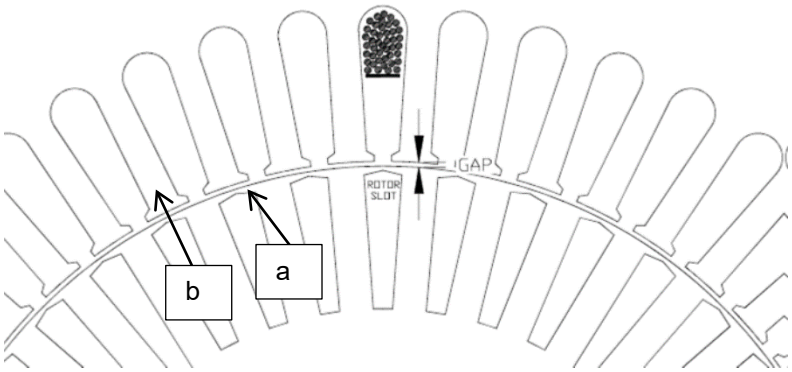
NOTE 1 There can be a cylindrical (even bearing clearance) or 2 lobes (elliptical) or 4 lobes sleeve bearing.
One can choose to reduce bearing clearance by their ratio depending upon type of bearing explained above.

NOTE 2 Since bearing clearances in normal operation are not symmetrical, and the shaft does not run concentric to the bearing, the lower shaft-to-bearing clearances are normally taken into account for capacitance calculations.

NOTE 3 Sleeve bearings often have Insulation between the shell and the bracket, and the series combination reduces the total bearing capacitance. This insulation is normally taken into account when calculating total bearing capacitance, except for those cases where the insulation capacitance has been bypassed with a conductor.

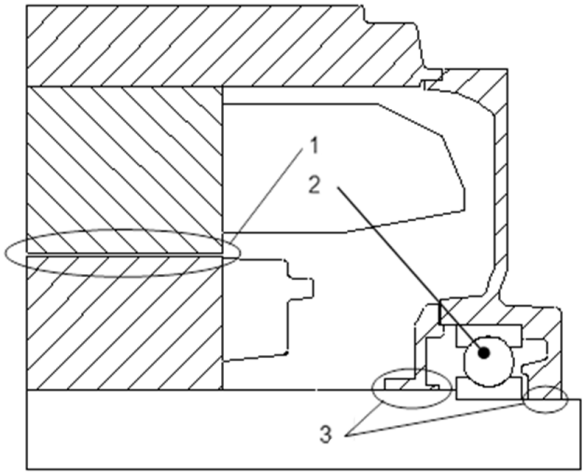
IEC

Figure H.1 – Capacitance stored in bearing clearance of sleeve bearing Between journal and outer bearing housing



IEC

Figure H.2 – Air-gap between stator and rotor



Key

1 Air gap

2 Bearing

3 Bearing caps

Figure H.3 – Typical surfaces that form capacitors from the motor shaft to ground

H.5 Energy “E” calculation for a rotating machine

Each of the capacitance values determined for the elements of the rotating machine is summed to form the overall capacitance value used to calculate the maximum discharge energy, E using Equation (H.1).

The calculated MIE needs to be be lower than specified in Table H.1 above for the respective applicable gas in order to allow and validate shaft-grounding device in hazardous location.

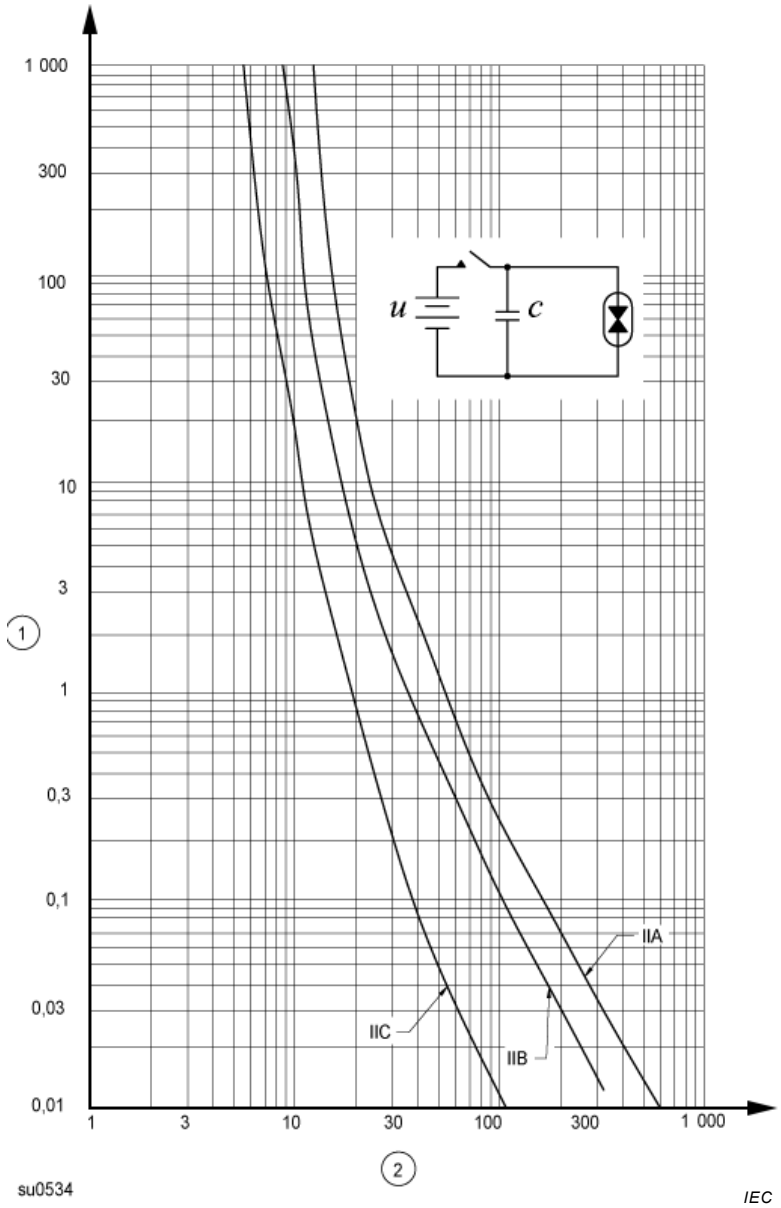
H.6 Assessment using reference curves

Figure H.4 can be used in the assessment. Generally, the following procedure shall be applied:

- determine the worst-case situation to obtain the voltage and capacitance for the rotating machine under consideration;
- check that the parameters of the resultant circuit are acceptable according to the reference curves in Figure H.4.

Any point to the left of the curve where the worst-case voltage and capacitance intersect will not be ignition capable for the material group indicated.

The circuit derived for assessment purposes may be tested using the spark-test apparatus if testing is preferred to assessment.



Key

1 capacitance C (µF)

2 minimum ignition voltage U (v)

Figure H.4 – Capacitive ignition curves

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