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IEC 60079-18

Edition 4.0 2014-12
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

Explosive atmospheres –
Part 18: Equipment protection by encapsulation “m”

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.260.20

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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EXPLOSIVE ATMOSPHERES –

Part 18: Equipment protection by encapsulation “m”

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

The contents of the corrigendum of July 2018 have been included in this copy.

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Standard IEC 60079-18 has been prepared by IEC technical committee 31: Equipment for explosive atmospheres.

This fourth edition cancels and replaces the third edition of IEC 60079-18 (2009), and constitutes a technical revision.

This International Standard is to be used in conjunction with IEC 60079-0, *Explosive atmospheres – Part 0: Equipment-General requirements*.

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

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Definitions deleted and moved to IEC 60079-0	3	X		
Heading modified /added to clarify which requirements are additional requirements for “ma” level of protection only	4	X		
Thermal conductivity added	5.2		X	
Note added that it is not a requirement of this standard that conformity to the manufacturer`s specification of the compound needs to be verified	5.3.2	X		
Clarification added	6.2.2	X		
Clarification added	7.1	X		
For the determination of faults options added and clarification given	7.2		X	
Additional information included in Figure 1	7.4.1	X		
“Varnish and similar coatings are not considered to be solid insulation.” was added in this section and deleted in the definition on 3.8	7.4.2	X		
For rigid, multi-layer printed wiring boards with through connections additional standards added	7.4.3.1		X	
Protection against inadmissible temperatures and damage to the cells	7.8.3			C1
Electrical protective devices clarified and additional possibilities added	7.9.2		X	
Thermal protective devices clarified and additional possibilities added	7.9.3		X	
2/3 voltage limitation deleted	7.9.3		X	
Determination of the maximum temperature for “Da” fixed	8.2.2			C2
Stabilization of the temperature	8.2.2			C3
Thermal endurance to heat	8.2.3.1		X	
Temperature fixed as reference service temperatures and tests given as alternatives	8.2.3.1.1		X	
For the dielectric strength test procedure alternative possibilities added	8.2.4.1		X	
Alternative test methods for the required pressure test for Group I and Group II electrical equipment added	8.2.6		X	
Sealing test for build-in protective devices	8.2.8		X	
For the dielectric strength test procedure alternative possibilities added	9.2		X	
Marking	10	X	X	

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Explanation of the Types of Significant Changes:

A) Definitions

1. 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.

2. 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.

3. 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 item 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 'Major technical changes'

C1 Clause 7.8.3 modified and additional requirements added for cells or batteries

C2 The flexibility given in IEC 60079-0 is replaced by a min. requirement. For level of protection "ma" equipment, designed for EPL "Da" the maximum surface temperature shall be determined with the equipment mounted in accordance with the manufacturer`s instructions, and surrounded on all available surfaces by dust with a layer thickness of at least 200 mm

C3 The increase of the temperature during the test can be a very slow process. The final temperature shall be considered to have been reached when the rate of rise of temperature does not exceed 1 K/24 h

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

FDIS	Report on voting
31/1152/FDIS	31/1168/RVD

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

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

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

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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EXPLOSIVE ATMOSPHERES –

Part 18: Equipment protection by encapsulation “m”

1 Scope

This part of IEC 60079 gives the specific requirements for the construction, testing and marking of electrical equipment, parts of electrical equipment and Ex components with the type of protection encapsulation “m” intended for use in explosive gas atmospheres or explosive dust atmospheres.

This part applies only for encapsulated electrical equipment, encapsulated parts of electrical equipment and encapsulated Ex components (hereinafter always referred to as “m” equipment) where the rated voltage does not exceed 11 kV.

The application of electrical equipment in atmospheres, which may contain explosive gas as well as combustible dust simultaneously, may require additional protective measures.

This standard does not apply to dusts of explosives, which do not require atmospheric oxygen for combustion, or to pyrophoric substances

This standard does not take account of any risk due to an emission of flammable or toxic gas from the dust.

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

2 Normative references

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

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

IEC 60079-7, *Explosive atmospheres – Part 7: Equipment protection by increased safety “e”*

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

IEC 60079-15, *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*

IEC 60079-26, *Explosive atmospheres – Part 26: Equipment with equipment protection level (EPL) Ga*

IEC 60079-31, *Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure “t”*

IEC 60127 (all parts), *Miniature fuses*

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

IEC 60691, *Thermal-links – Requirements and application guide*

IEC 60730-2-9, *Automatic electrical controls for household and similar use – Part 2-9: Particular requirements for temperature sensing controls*

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

~~IEC 61241-11, *Electrical apparatus for use in the presence of combustible dust – Part 11: Protection by intrinsic safety 'iD'*~~

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61558-1, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

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

IEC 62326-4-1, *Printed boards – Part 4: Rigid multilayer printed boards with interlayer connections – Sectional specification – Section 1: Capability detail specification – Performance levels A, B and C*

~~ISO 62, *Plastics – Determination of water absorption*~~

ANSI/UL 248~~-1, *(all parts)*~~, *Standard for low-voltage fuses ~~– Part 1: General requirements~~*

ANSI/UL 746B, *Standard for polymeric materials – Long term property evaluations*

ANSI/UL 796, *Printed-Wiring Boards*

IPC-A-600, *Acceptability of Printed Boards*

IPC-6012, *Qualification and Performance Specification for Rigid Printed Boards*

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IEC 60079-18

Edition 4.0 2014-12

INTERNATIONAL STANDARD

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Explosive atmospheres –
Part 18: Equipment protection by encapsulation “m”

Atmosphères explosives –
Partie 18: Protection du matériel par encapsulage "m"

IEC 60079-18:2014-12(en-fr)

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EXPLOSIVE ATMOSPHERES –

Part 18: Equipment protection by encapsulation “m”

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Thermal conductivity added	5.2		X	
Note added that it is not a requirement of this standard that conformity to the manufacturer`s specification of the compound needs to be verified	5.3.2	X		
Clarification added	6.2.2	X		
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“Varnish and similar coatings are not considered to be solid insulation.” was added in this section and deleted in the definition on 3.8	7.4.2	X		
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Electrical protective devices clarified and additional possibilities added	7.9.2		X	
Thermal protective devices clarified and additional possibilities added	7.9.3		X	
2/3 voltage limitation deleted	7.9.3		X	
Determination of the maximum temperature for “Da” fixed	8.2.2			C2
Stabilization of the temperature	8.2.2			C3
Thermal endurance to heat	8.2.3.1		X	
Temperature fixed as reference service temperatures and tests given as alternatives	8.2.3.1.1		X	
For the dielectric strength test procedure alternative possibilities added	8.2.4.1		X	
Alternative test methods for the required pressure test for Group I and Group II electrical equipment added	8.2.6		X	
Sealing test for build-in protective devices	8.2.8		X	
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Marking	10	X	X	

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Explanation of the Types of Significant Changes:

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C2 The flexibility given in IEC 60079-0 is replaced by a min. requirement. For level of protection "ma" equipment, designed for EPL "Da" the maximum surface temperature shall be determined with the equipment mounted in accordance with the manufacturer`s instructions, and surrounded on all available surfaces by dust with a layer thickness of at least 200 mm

C3 The increase of the temperature during the test can be a very slow process. The final temperature shall be considered to have been reached when the rate of rise of temperature does not exceed 1 K/24 h

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EXPLOSIVE ATMOSPHERES –

Part 18: Equipment protection by encapsulation “m”

1 Scope

This part of IEC 60079 gives the specific requirements for the construction, testing and marking of electrical equipment, parts of electrical equipment and Ex components with the type of protection encapsulation “m” intended for use in explosive gas atmospheres or explosive dust atmospheres.

This part applies only for encapsulated electrical equipment, encapsulated parts of electrical equipment and encapsulated Ex components (hereinafter always referred to as “m” equipment) where the rated voltage does not exceed 11 kV.

The application of electrical equipment in atmospheres, which may contain explosive gas as well as combustible dust simultaneously, may require additional protective measures.

This standard does not apply to dusts of explosives, which do not require atmospheric oxygen for combustion, or to pyrophoric substances

This standard does not take account of any risk due to an emission of flammable or toxic gas from the dust.

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

2 Normative references

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IEC 60079-7, *Explosive atmospheres – Part 7: Equipment protection by increased safety “e”*

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

IEC 60079-15, *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*

IEC 60079-26, *Explosive atmospheres – Part 26: Equipment with equipment protection level (EPL) Ga*

IEC 60079-31, *Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure “t”*

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

IEC 60691, *Thermal-links – Requirements and application guide*

IEC 60730-2-9, *Automatic electrical controls for household and similar use – Part 2-9: Particular requirements for temperature sensing controls*

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

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61558-1, *Safety of power transformers, power supplies, reactors and similar products – Part 1: General requirements and tests*

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

IEC 62326-4-1, *Printed boards – Part 4: Rigid multilayer printed boards with interlayer connections – Sectional specification – Section 1: Capability detail specification – Performance levels A, B and C*

ANSI/UL 248 *(all parts)*, *Standard for low-voltage fuses*

ANSI/UL 746B, *Standard for polymeric materials – Long term property evaluations*

ANSI/UL 796, *Printed-Wiring Boards*

IPC-A-600, *Acceptability of Printed Boards*

IPC-6012, *Qualification and Performance Specification for Rigid Printed Boards*

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ATMOSPHÈRES EXPLOSIVES –

Partie 18: Protection du matériel par encapsulage "m"

AVANT-PROPOS

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La Norme internationale IEC 60079-18 a été établie par le comité d'études 31 de l'IEC: Matériel pour atmosphères explosives.

Cette quatrième édition annule et remplace la troisième édition de l'IEC 60079-18 (2009). Cette édition constitue une révision technique.

Cette Norme Internationale doit être utilisée conjointement avec l'IEC 60079-0, *Atmosphères explosives – Partie 0: Matériel – Exigences générales*.

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Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

		Type		
Explication de l'importance des modifications	**Article**	**Modifications mineures et rédactionnelles**	**Extension**	**Modifications techniques majeures**
Définitions supprimées et déplacées vers l'IEC 60079-0	3	X		
Titre modifié/ajouté pour clarifier les exigences qui sont supplémentaires pour "ma" niveau de protection uniquement	4	X		
Ajout de la conductivité thermique	5.2		X	
Ajout d'une note spécifiant que la vérification de la conformité du composé à la spécification du constructeur n'est pas une exigence de la présente Norme	5.3.2	X		
Ajout d'une clarification	6.2.2	X		
Ajout d'une clarification	7.1	X		
Ajout d'options et d'une clarification pour la détermination des défauts	7.2		X	
Ajout d'informations supplémentaires à la Figure 1	7.4.1	X		
La phrase "Les vernis et revêtements similaires ne sont pas considérés comme des isolations solides." a été ajoutée à cette partie et supprimée de la définition 3.8	7.4.2	X		
Ajout de normes supplémentaires pour les cartes de circuits imprimés rigides multicouches avec connexions traversantes	7.4.3.1		X	
Protection contre les températures excessives et contre la détérioration des piles et accumulateurs	7.8.3			C1
Ajout de possibilités supplémentaires et clarifiées pour les dispositifs de protection électrique	7.9.2		X	
Ajout de possibilités supplémentaires et clarifiées pour les dispositifs de protection thermique	7.9.3		X	
Suppression de la limitation à 2/3 de la tension	7.9.3		X	
Détermination de la température maximale pour "Da"	8.2.2			C2
Stabilisation de la température	8.2.2			C3
Endurance thermique à la chaleur	8.2.3.1		X	
Détermination de la température comme température de service de référence et indication d'autres possibilités d'essais	8.2.3.1.1		X	
Ajout d'autres possibilités pour la procédure d'essai de rigidité diélectrique	8.2.4.1		X	
Ajout d'autres méthodes d'essai pour l'essai de pression exigé du matériel électrique des groupes I et II	8.2.6		X	
Essai d'étanchéité pour les dispositifs de protection incorporés	8.2.8		X	
Ajout d'autres possibilités pour la procédure d'essai de rigidité diélectrique	9.2		X	
Marquage	10		X	

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Explication des types de modifications majeures:

A) Définitions

1. **Modifications mineures et rédactionnelles:**
   - Clarification
   - Diminution des exigences techniques
   - Modification technique mineure
   - Corrections rédactionnelles

Ces modifications portent sur les exigences et sont de nature rédactionnelle ou technique mineure. Elles comprennent des modifications de formulation destinées à clarifier les exigences techniques sans apporter de modification technique ni réduire le niveau actuel de l'exigence.

2. **Extension:**
   - Ajout d'options techniques

Ces modifications ajoutent de nouvelles exigences techniques ou modifient les exigences existantes de façon à fournir de nouvelles options, mais sans augmenter les exigences relatives au matériel qui était totalement conforme à la précédente norme. Ces modifications ne sont donc pas à prendre en compte dans le cas de produits conformes à la précédente édition.

3. **Modifications techniques majeures:**
   - ajout d'exigences techniques
   - augmentation des exigences techniques

Ces modifications sont apportées aux exigences techniques (ajout, augmentation du niveau ou suppression) de telle façon qu'un produit conforme à la précédente édition n'a pas toujours la capacité de satisfaire aux exigences indiquées dans la dernière édition. Ces modifications sont à prendre en compte dans le cas de produits conformes à la précédente édition. L'élément B) ci-dessous fournit des informations supplémentaires sur ces modifications.

Note Ces modifications reflètent les connaissances technologiques actuelles. Cependant, il convient que ces modifications n'aient pas d'influence sur le matériel déjà sur le marché.

B) Informations sur l'origine des "Modifications techniques majeures"

C1 Article 7.8.3 Modification des exigences et ajout d'exigences supplémentaires pour les piles et accumulateurs

C2 La flexibilité indiquée dans l'IEC 60079-0 est remplacée par une exigence min. Pour le niveau de protection du matériel "ma", conçu pour l'EPL (equipment protection level – niveau de protection du matériel) "Da", la température maximale de surface doit être déterminée avec le matériel monté conformément aux instructions du constructeur et entouré sur toute la surface disponible par une couche de poussière d'une épaisseur d'au moins 200 mm

C3 L'échauffement qui se produit au cours de l'essai peut être un processus très lent. Il doit être considéré que la température finale a été atteinte quand la vitesse d'échauffement ne dépasse pas 1 K/24 h.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
31/1152/FDIS	31/1168/RDV

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60079, publiées sous le titre général *Atmosphères explosives*, peut être consultée sur le site web de l'IEC.

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Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- transformée en Norme internationale,
- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

Le contenu du corrigendum de juillet 2018 a été pris en considération dans cet exemplaire.

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ATMOSPHÈRES EXPLOSIVES –

Partie 18: Protection du matériel par encapsulage "m"

1 Domaine d'application

La présente partie de l'IEC 60079 définit les exigences spécifiques à la construction, aux essais et au marquage des matériels électriques, des parties de matériels électriques et des composants Ex protégés par encapsulage de type "m" et destinés à une utilisation dans les atmosphères explosives gazeuses ou les atmosphères explosives poussiéreuses.

La présente partie ne s'applique qu'aux matériels électriques protégés par encapsulage, aux parties de matériel électrique protégées par encapsulage et aux composants Ex protégés par encapsulage (ci-après toujours dénommés matériel "m") pour lesquels la tension assignée n'excède pas 11 kV.

L'utilisation du matériel électrique en atmosphère pouvant contenir simultanément du gaz explosif et des poussières combustibles peut nécessiter des mesures de protection supplémentaires.

La présente Norme ne s'applique pas aux poussières d'explosifs qui n'exigent pas d'oxygène de l'air pour leur combustion ni aux substances pyrophoriques.

La présente Norme ne tient pas compte des risques, quels qu'ils soient, résultant d'une émission de gaz inflammable ou toxique provenant de la poussière.

La présente Norme complète et modifie les exigences générales de l'IEC 60079-0. Si une exigence de la présente Norme est en conflit avec une exigence de l'IEC 60079-0, l'exigence de la présente Norme a préséance.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60079-0, *Atmosphères explosives – Partie 0: Matériel – Exigences générales*

IEC 60079-7, *Atmosphères explosives – Partie 7: Protection de l'équipement par sécurité augmentée "e"*

IEC 60079-11, *Atmosphères explosives – Partie 11: Protection de l'équipement par sécurité intrinsèque "i"*

IEC 60079-15, *Atmosphères explosives – Partie 15: Protection du matériel par mode de protection "n"*

IEC 60079-26, *Atmosphères explosives – Partie 26: Matériel d'un niveau de protection du matériel (EPL) Ga*

IEC 60079-31, *Atmosphères explosives – Partie 31: Protection contre l'inflammation de poussières par enveloppe "t" relative au matériel*

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IEC 60127 (toutes les parties), *Coupe-circuit miniatures*

IEC 60243-1, *Rigidité diélectrique des matériaux isolants – Méthodes d'essai – Partie 1: Essais aux fréquences industrielles*

IEC 60691, *Protecteurs thermiques – Prescriptions et guide d'application*

IEC 60730-2-9, *Dispositifs de commande électrique automatiques à usage domestique et analogue – Partie 2-9: Règles particulières pour les dispositifs de commande thermosensibles*

IEC 60738-1, *Thermistances – Coefficient de température positif à chauffage direct – Partie 1: Spécification générique*

IEC 61140, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

IEC 61558-1, *Sécurité des transformateurs, alimentations, bobines d'inductance et produits analogues – Partie 1: Exigences générales et essais*

IEC 61558-2-6, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-6: Règles particulières et essais pour les transformateurs de sécurité et les blocs d'alimentation incorporant des transformateurs de sécurité*

IEC 62326-4-1, *Cartes imprimées – Partie 4: Cartes imprimées multicouches rigides avec connexions intercouches – Spécification intermédiaire – Section 1: Spécification particulière d'agrément: Niveaux de performances A, B et C*

ANSI/UL 248 *(toutes parties)*, *Standard for low-voltage fuses*

ANSI/UL 746B, *Standard for polymeric materials – Long-term property evaluations*

ANSI/UL 796, *Printed-Wiring Boards*

IPC-A-600, *Acceptability of Printed Boards*

IPC-6012, *Qualification and Performance Specification for Rigid Printed Boards*