

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Explosive atmospheres –
Part 11: Equipment protection by intrinsic safety "i"**

**Atmosphères explosives –
Partie 11: Protection de l'appareil par sécurité intrinsèque "i"**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2023 IEC, Geneva, Switzerland

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

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

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

About the IEC

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

About IEC publications

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

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

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

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

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

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications preview. With a subscription you will always have access to up-to-date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Explosive atmospheres –
Part 11: Equipment protection by intrinsic safety "i"**

**Atmosphères explosives –
Partie 11: Protection de l'appareil par sécurité intrinsèque "i"**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 29.260.20

ISBN 978-2-8322-7447-7

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

| | |
|---|----|
| FOREWORD..... | 10 |
| 1 Scope..... | 23 |
| 2 Normative references | 30 |
| 3 Terms, definitions and abbreviated terms | 31 |
| 3.1 Terms and definitions..... | 31 |
| 3.2 Abbreviated terms..... | 35 |
| 4 Equipment grouping, classification and Levels of Protection of apparatus..... | 35 |
| 5 Ignition compliance requirements | 36 |
| 5.1 General..... | 36 |
| 5.2 Conditions for assessment..... | 36 |
| 5.2.1 General | 36 |
| 5.2.2 Level of Protection "ia" | 37 |
| 5.2.3 Level of Protection "ib" | 38 |
| 5.2.4 Level of Protection "ic"..... | 38 |
| 5.2.5 Non-shock hazard equipment or systems..... | 39 |
| 5.3 Spark ignition compliance | 39 |
| 5.3.1 General | 39 |
| 5.3.2 Levels of Protection "ia" and "ib"..... | 40 |
| 5.3.3 Level of Protection "ic"..... | 40 |
| 5.3.4 Application of safety factors..... | 41 |
| 5.3.5 Circuits without controlled semiconductor limitation | 41 |
| 5.3.6 Circuits with controlled semiconductor limitation | 42 |
| 5.4 Thermal ignition compliance..... | 43 |
| 5.4.1 General | 43 |
| 5.4.2 Temperature of small components for Group I and Group II..... | 43 |
| 5.4.3 Wiring within intrinsically safe apparatus for Group I and Group II | 43 |
| 5.4.4 PCB tracks for Group I and Group II | 45 |
| 5.4.5 Intrinsically safe apparatus and component temperature for dusts | 48 |
| 5.5 Simple apparatus..... | 48 |
| 6 Apparatus construction..... | 49 |
| 6.1 General..... | 49 |
| 6.2 Enclosures..... | 49 |
| 6.2.1 General | 49 |
| 6.2.2 Apparatus complying with Table 7 | 50 |
| 6.2.3 Apparatus complying with Table 8 or Table 9..... | 50 |
| 6.2.4 Enclosures for Group IIIC intrinsically safe apparatus..... | 50 |
| 6.2.5 Protection of separations | 50 |
| 6.3 Connection facilities for external circuits | 51 |
| 6.3.1 Terminals | 51 |
| 6.3.2 Earth Terminals..... | 53 |
| 6.3.3 Plugs and sockets | 53 |
| 6.3.4 Permanently connected cable..... | 53 |
| 6.3.5 Connections and accessories for intrinsically safe apparatus for use in non-hazardous area..... | 54 |
| 6.4 Internal connections and connectors | 55 |
| 6.4.1 General | 55 |
| 6.4.2 Infallible connections | 55 |

| | | |
|--------|---|----|
| 6.4.3 | Connectors for internal connections, plug-in cards and components | 57 |
| 6.4.4 | Earth conductors and connections | 57 |
| 6.5 | Separation of conductive parts | 58 |
| 6.5.1 | Separations on which intrinsic safety depends | 58 |
| 6.5.2 | Separation distances according to Table 7 | 58 |
| 6.5.3 | Reduced separation distances | 59 |
| 6.5.4 | Failure of separations | 59 |
| 6.5.5 | Voltage between conductive parts | 65 |
| 6.5.6 | Types of separation | 65 |
| 6.5.7 | Composite separations | 72 |
| 6.5.8 | Printed circuit board assemblies | 73 |
| 6.5.9 | Separation by metal parts | 75 |
| 6.5.10 | Separation by non-metallic insulating partitions | 75 |
| 6.5.11 | Insulation of internal wiring | 76 |
| 6.6 | Encapsulation | 76 |
| 6.6.1 | General | 76 |
| 6.6.2 | Encapsulation used for the exclusion of explosive atmospheres | 77 |
| 6.6.3 | Mechanical protection to avoid access to parts | 80 |
| 6.6.4 | Encapsulation used for protection of a fuse | 81 |
| 6.6.5 | Encapsulation used to provide separation | 81 |
| 6.6.6 | Encapsulation used to enhance the rating of protective components | 81 |
| 6.6.7 | Free space within the encapsulation | 81 |
| 6.7 | Specification of coating, encapsulation materials | 83 |
| 6.8 | Protection against polarity reversal | 83 |
| 6.9 | Dielectric strength requirement | 83 |
| 7 | Characteristics and failure of components and assemblies | 84 |
| 7.1 | Rating of components on which intrinsic safety depends | 84 |
| 7.2 | Failure of components | 84 |
| 7.3 | Manufacturing variation | 84 |
| 7.4 | Resistors | 85 |
| 7.4.1 | General | 85 |
| 7.4.2 | Resistors on which intrinsic safety depends | 85 |
| 7.5 | Capacitors | 86 |
| 7.5.1 | General | 86 |
| 7.5.2 | Capacitors on which intrinsic safety depends | 86 |
| 7.5.3 | Blocking capacitors | 87 |
| 7.5.4 | Infallible filter capacitors | 87 |
| 7.6 | Inductors and windings | 88 |
| 7.6.1 | General | 88 |
| 7.6.2 | Inductors on which intrinsic safety depends | 88 |
| 7.6.3 | Infallibly insulated inductors | 88 |
| 7.6.4 | Damping windings | 89 |
| 7.6.5 | Common mode choke coils (EMI suppression filters) | 89 |
| 7.7 | Semiconductors | 90 |
| 7.7.1 | Failure of semiconductors | 90 |
| 7.7.2 | Semiconductors on which intrinsic safety depends | 91 |
| 7.7.3 | Transient effects on semiconductors on which intrinsic safety depends | 91 |
| 7.7.4 | Semiconductors in shunt voltage limiters | 91 |
| 7.7.5 | Shunt assembly on which intrinsic safety depends | 92 |

| | | |
|--------|--|-----|
| 7.7.6 | Safety assemblies infallible against failure to limit voltage | 92 |
| 7.7.7 | Semiconductor current limiters | 92 |
| 7.7.8 | Use of programmable components | 92 |
| 7.8 | Transformers | 93 |
| 7.8.1 | General | 93 |
| 7.8.2 | Transformers on which intrinsic safety depends | 93 |
| 7.8.3 | Construction of transformers on which intrinsic safety depends | 93 |
| 7.8.4 | Protective measures for transformers on which intrinsic safety depends for Levels of Protection "ia" and "ib" | 94 |
| 7.8.5 | Requirements for transformers for Level of Protection "ic" | 95 |
| 7.9 | Relays | 95 |
| 7.9.1 | General | 95 |
| 7.9.2 | Relays on which intrinsic safety depends | 96 |
| 7.10 | Signal isolators | 97 |
| 7.10.1 | General | 97 |
| 7.10.2 | Signal isolators on which intrinsic safety depends | 97 |
| 7.10.3 | Signal isolators between intrinsically safe and non-intrinsically safe circuits | 98 |
| 7.10.4 | Signal isolators between separate intrinsically safe circuits | 98 |
| 7.11 | Fuses | 98 |
| 7.12 | Primary and secondary cells and batteries | 100 |
| 7.12.1 | General | 100 |
| 7.12.2 | Construction of cells and batteries used in intrinsically safe apparatus | 100 |
| 7.12.3 | Electrolyte leakage | 101 |
| 7.12.4 | Ventilation | 101 |
| 7.12.5 | Cell voltages | 101 |
| 7.12.6 | Batteries in equipment protected by different Types of Protection | 102 |
| 7.12.7 | Batteries used and replaced in explosive atmospheres | 102 |
| 7.12.8 | Replaceable batteries used but not replaced in explosive atmospheres | 102 |
| 7.12.9 | External contacts for charging batteries | 102 |
| 7.13 | Piezoelectric devices | 102 |
| 7.14 | Cells for the detection of gases | 103 |
| 7.14.1 | Electrochemical | 103 |
| 7.14.2 | Catalytic | 103 |
| 7.15 | Supercapacitors | 103 |
| 7.16 | Thermal devices | 104 |
| 7.16.1 | General | 104 |
| 7.16.2 | Thermal devices used to limit temperature | 104 |
| 7.16.3 | PPTC devices used to limit current | 105 |
| 7.17 | Mechanical switches | 106 |
| 8 | Supplementary requirements for specific apparatus | 106 |
| 8.1 | Diode safety barriers | 106 |
| 8.1.1 | General | 106 |
| 8.1.2 | Construction | 106 |
| 8.2 | FISCO apparatus | 106 |
| 9 | Type verifications and type tests | 107 |
| 9.1 | Spark ignition test | 107 |
| 9.1.1 | General | 107 |
| 9.1.2 | Spark test apparatus and its use | 107 |

| | | |
|--------|---|-----|
| 9.1.3 | Test gas mixtures and spark test apparatus calibration current..... | 108 |
| 9.2 | Spark ignition assessment using reference curves and tables..... | 109 |
| 9.2.1 | General..... | 109 |
| 9.2.2 | Assessment of simple resistive circuit..... | 109 |
| 9.2.3 | Assessment of simple capacitive circuits..... | 110 |
| 9.2.4 | Assessment of Simple Inductive Circuits..... | 112 |
| 9.2.5 | Determination of L_0/R_0 for resistance limited power source..... | 113 |
| 9.2.6 | Circuits with both inductance and capacitance..... | 114 |
| 9.3 | Temperature tests..... | 114 |
| 9.4 | Mechanical tests..... | 115 |
| 9.4.1 | Casting compound..... | 115 |
| 9.4.2 | Acceptability of encapsulated or coated fuses..... | 115 |
| 9.4.3 | Partitions..... | 116 |
| 9.4.4 | Cable pull test..... | 116 |
| 9.5 | Current carrying capacity of infallible printed circuit board connection..... | 116 |
| 9.6 | Dielectric strength tests..... | 116 |
| 9.7 | Qualification of solid insulation and distance through casting compound for application of reduced separations..... | 116 |
| 9.7.1 | General..... | 116 |
| 9.7.2 | Preconditioning..... | 117 |
| 9.7.3 | AC power frequency voltage test..... | 117 |
| 9.7.4 | Partial discharge test..... | 118 |
| 9.8 | Type tests for PCB coatings..... | 119 |
| 9.9 | Differential Leakage current tests for signal isolators..... | 119 |
| 9.10 | Isolator tests..... | 120 |
| 9.10.1 | General..... | 120 |
| 9.10.2 | Thermal conditioning and dielectric test..... | 120 |
| 9.10.3 | Dielectric and short circuit test..... | 121 |
| 9.11 | Tests for intrinsically safe apparatus containing piezoelectric devices..... | 122 |
| 9.12 | Tests for PTC devices..... | 122 |
| 9.13 | Determination of parameters of loosely specified components..... | 123 |
| 9.14 | Tests for cells, batteries and supercapacitors..... | 123 |
| 9.14.1 | Conditions for testing..... | 123 |
| 9.14.2 | Electrolyte leakage test for cells, batteries and supercapacitors..... | 124 |
| 9.14.3 | Spark ignition and surface temperature of cells, batteries or supercapacitors..... | 125 |
| 9.14.4 | Battery container pressure tests..... | 126 |
| 9.14.5 | Battery resistance..... | 126 |
| 9.15 | Determination of storable energy in common mode chokes..... | 126 |
| 9.16 | Type tests for components protected by time dependent current limitation..... | 128 |
| 9.17 | Transformer tests..... | 129 |
| 9.17.1 | General..... | 129 |
| 9.17.2 | Mains transformers for Level of Protection "ia" and "ib"..... | 130 |
| 9.17.3 | Transformers galvanically isolated from the mains supply for Levels of Protection "ia" and "ib"..... | 130 |
| 9.17.4 | Transformers for Level of Protection "ic"..... | 131 |
| 10 | Routine verifications and tests..... | 131 |
| 10.1 | Alternative reduced spacings..... | 131 |
| 10.2 | Routine tests for diode safety barriers..... | 131 |

| | | |
|-----------------------|--|-----|
| 10.2.1 | Completed barriers | 131 |
| 10.2.2 | Diodes for 2-diode "ia" barriers | 131 |
| 10.3 | Routine tests for transformers | 131 |
| 10.3.1 | Levels of Protection "ia" and "ib" | 131 |
| 10.3.2 | Level of Protection "ic" | 132 |
| 10.4 | Routine verification of conformal coating and encapsulation | 132 |
| 11 | Marking | 133 |
| 11.1 | Intrinsically safe apparatus and associated apparatus | 133 |
| 11.1.1 | General | 133 |
| 11.1.2 | Intrinsic safety parameters | 133 |
| 11.1.3 | FISCO | 133 |
| 11.1.4 | Marking of connection facilities | 134 |
| 11.1.5 | Non-hazardous area accessory | 134 |
| 11.2 | Warning markings | 134 |
| 12 | Instructions | 135 |
| 12.1 | General | 135 |
| 12.2 | Specific Conditions of Use | 135 |
| Annex A (normative) | Spark ignition reference curves | 137 |
| Annex B (normative) | Spark test apparatus for intrinsically safe circuits | 161 |
| B.1 | Principle | 161 |
| B.2 | Spark test apparatus | 161 |
| B.3 | Spark test apparatus sensitivity | 162 |
| B.4 | Preparation and cleaning of tungsten wire | 162 |
| B.5 | Conditioning a new cadmium disc | 163 |
| B.6 | Limitations of the spark test apparatus | 163 |
| B.7 | Modification of spark test apparatus for use at higher currents | 164 |
| Annex C (informative) | Measurement of creepage distances, clearances and separation distances through casting compound and through solid insulation | 169 |
| C.1 | Clearances and separation distances through casting compound and through solid insulation | 169 |
| C.2 | Creepage distances | 170 |
| C.3 | Examples for the application of an ambient pressure correction factor | 171 |
| Annex D (normative) | Excess transient energy test | 174 |
| D.1 | Overview | 174 |
| D.2 | Circuit configuration | 175 |
| D.3 | Test equipment | 176 |
| D.4 | Test load | 177 |
| D.5 | Supply voltage | 177 |
| D.6 | Supply change tests | 177 |
| D.7 | Load change tests | 178 |
| D.8 | Transient energy calculation | 178 |
| Annex E (normative) | FISCO – Apparatus requirements | 180 |
| E.1 | Overview | 180 |
| E.2 | Apparatus requirements | 180 |
| E.2.1 | General | 180 |
| E.2.2 | FISCO power supplies | 180 |
| E.3 | FISCO field devices | 181 |
| E.3.1 | General | 181 |

| | | |
|-----------------------|--|-----|
| E.3.2 | Additional requirements of "ia" and "ib" FISCO field devices | 182 |
| E.3.3 | Additional requirement of "ic" FISCO field devices | 182 |
| E.3.4 | Terminator | 182 |
| E.3.5 | Simple apparatus | 182 |
| Annex F (normative) | Ignition testing of semiconductor limiting power supply circuits | 184 |
| F.1 | Overview | 184 |
| F.2 | Initial test | 184 |
| F.3 | Subsequent tests | 184 |
| F.4 | Examples of pass and fail | 185 |
| Annex G (normative) | Universal output characteristics | 191 |
| G.1 | Overview | 191 |
| G.2 | Linear source | 191 |
| G.3 | Non-linear source | 191 |
| G.4 | Curves | 192 |
| Annex H (informative) | Examples of marking | 203 |
| H.1 | General | 203 |
| H.2 | Self-contained intrinsically safe apparatus | 203 |
| H.3 | Intrinsically safe apparatus supplied by other intrinsically safe circuits | 203 |
| H.4 | Associated apparatus | 204 |
| H.5 | Associated apparatus protected by a flameproof enclosure | 204 |
| H.6 | Intrinsically safe apparatus Level of Protection "ic" | 204 |
| H.7 | Intrinsically safe apparatus Level of Protection "ib" with "ia" outputs | 205 |
| H.8 | FISCO | 205 |
| H.8.1 | Power supply | 205 |
| H.8.2 | Field device | 205 |
| H.8.3 | Terminator | 206 |
| H.8.4 | Dual marked field device | 206 |
| Annex I (informative) | Overview of tests on enclosures or parts of enclosures | 207 |
| Bibliography | | 209 |
| Figure 1 | – Separation at terminals | 52 |
| Figure 2 | – Examples of independent and non-independent connecting elements | 56 |
| Figure 3 | – Example of separation of conductive parts | 64 |
| Figure 4 | – Determination of creepage distances and clearance | 71 |
| Figure 5 | – Creepage distances and clearances on PCBAs | 74 |
| Figure 6 | – Encapsulation used without a separate external enclosure | 78 |
| Figure 7 | – Complete enclosure with no user removable covers or openings | 78 |
| Figure 8 | – Enclosure where the compound forms one of the external walls | 79 |
| Figure 9 | – Enclosure with cover | 79 |
| Figure 10 | – Moulding over un-mounted components | 80 |
| Figure 11 | – Moulding over components mounted on a PCB | 80 |
| Figure 12 | – Example of a simple resistive circuit | 109 |
| Figure 13 | – Example of simple capacitive circuit | 110 |
| Figure 14 | – Effective capacitance | 111 |
| Figure 15 | – Example of simple inductive circuit | 112 |
| Figure 16 | – Test voltages | 119 |

| | |
|---|-----|
| Figure 17 – Recommended bias circuit for Differential Leakage measurement | 120 |
| Figure 18 – Inductor test circuit..... | 127 |
| Figure 19 – Measured oscillation | 128 |
| Figure A.1 – Resistive circuits..... | 138 |
| Figure A.2 – Group I capacitive circuits..... | 139 |
| Figure A.3 – Group II capacitive circuits..... | 140 |
| Figure A.4 – Inductive circuits of Group II | 141 |
| Figure A.5 – Group I inductive circuits | 142 |
| Figure A.6 – Group IIC inductive circuits | 143 |
| Figure B.1 – Spark test apparatus for intrinsically safe circuits..... | 165 |
| Figure B.2 – Cadmium contact disc..... | 166 |
| Figure B.3 – Wire holder | 166 |
| Figure B.4 – Example of a practical design of spark test apparatus..... | 167 |
| Figure B.5 – Arrangement for fusing tungsten wires | 168 |
| Figure C.1 – Measurement of clearance..... | 169 |
| Figure C.2 – Measurement of composite distances | 169 |
| Figure C.3 – Measurement of creepage | 170 |
| Figure C.4 – Composite separation including creepage..... | 171 |
| Figure C.5 – PCB with two coated components designed for ambient pressure 60 kPa to 110 kPa | 171 |
| Figure C.6 – PCB with 3 mm slot designed for ambient pressure 60 kPa to 110 kPa | 172 |
| Figure D.1 – Example circuit configuration..... | 175 |
| Figure D.2 – Example output voltage, current, power and energy measured during a load transient..... | 179 |
| Figure E.1 – Typical FISCO system | 183 |
| Figure F.1 – Safety factor vs ignition probability..... | 190 |
| Figure G.1 – Example of an output characteristic for Group IIC..... | 192 |
| Figure G.2 – Limit curve diagram for universal source characteristic – Group IIC..... | 197 |
| Figure G.3 – Limit curve diagram for universal source characteristic – Group IIB | 202 |
| Figure I.1 – Tests for enclosures or parts of enclosures for separation distances complying with Table 7 | 207 |
| Figure I.2 – Tests for enclosures or parts of enclosures for separation distances complying with Table 8 or Table 9..... | 208 |
| | |
| Table 1 – Applicability of specific clauses of IEC 60079-0..... | 24 |
| Table 2 – List of abbreviated terms used..... | 35 |
| Table 3 – Temperature classification of copper wiring for ambient temperature ≤ 40 °C | 45 |
| Table 4 – Temperature classification of tracks on PCBs..... | 47 |
| Table 5 – Maximum permitted power dissipation within a component immersed in dust..... | 48 |
| Table 6 – Requirements for infallible circuit board tracks and vias | 57 |
| Table 7 – Clearances, creepage distances and separations | 61 |
| Table 8 – Reduced separations..... | 62 |
| Table 9 – Reduced separations for Level of Protection "ic" | 63 |
| Table 10 – Creepage distance and clearance X in Figure 4..... | 67 |

| | |
|---|-----|
| Table 11 – Minimum thickness of compound adjacent to individual free space for Group I and Group II | 82 |
| Table 12 – Minimum thickness of compound adjacent to individual free space for Group III | 82 |
| Table 13 – Rating and failure modes of resistors | 85 |
| Table 14 – Rating and failure modes of capacitors | 87 |
| Table 15 – Rating and failure modes of inductors | 88 |
| Table 16 – Rating and failure modes of semiconductors | 91 |
| Table 17 – Minimum foil thickness or minimum wire diameter of the screen | 94 |
| Table 18 – Rating and failure modes of signal isolators | 97 |
| Table 19 – Rating and failure modes of temperature sensors | 104 |
| Table 20 – Rating and failure modes of switching thermal devices | 105 |
| Table 21 – Rating and failure modes of PTC devices used to limit temperature | 105 |
| Table 22 – Rating and failure modes of PPTC devices used to limit current | 105 |
| Table 23 – Compositions of explosive test mixtures adequate for 1,0 safety factor | 108 |
| Table 24 – Compositions of explosive test mixtures adequate for 1,5 safety factor | 108 |
| Table 25 – Permitted reduction of effective capacitance when protected by a series resistance | 112 |
| Table 26 – Routine test voltages for transformers | 132 |
| Table 27 – Text of warning markings | 134 |
| Table 28 – Concerns addressed by Specific Conditions of Use | 136 |
| Table A.1 – Permitted short circuit current corresponding to the voltage and the equipment group | 144 |
| Table A.2 – Permitted capacitance corresponding to the voltage and the equipment group | 151 |
| Table D.1 – Energy limits by equipment group | 174 |
| Table E.1 – Assessment of maximum output current for use with "ia" and "ib" FISCO rectangular supplies | 181 |
| Table E.2 – Assessment of maximum output current for use with "ic" FISCO rectangular supplies | 181 |
| Table F.1 – Terms used in Annex F | 185 |
| Table F.2 – Sequence of tests | 186 |
| Table F.3 – Safety factor provided by several explosive test mixtures that may be used for the tests in Table F.2 | 187 |
| Table F.4 – Example of a Group I circuit with characteristics described by 'Pr – Table F.4 – PASS' of Figure F.1 | 188 |
| Table F.5 – Example of a Group I circuit with characteristics described by 'Pr – Table F.5 – FAIL' of Figure F.1 | 189 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 11: Equipment protection by intrinsic safety "i"

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60079-11 has been prepared by subcommittee 31G: Intrinsically safe apparatus, of IEC technical committee 31: Equipment for explosive atmospheres. It is an International Standard.

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