

# INTERNATIONAL STANDARD



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

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

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://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](http://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 It also gives information on projects, replaced and withdrawn publications.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](http://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](http://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](mailto:sales@iec.ch).

#### IEC Products & Services Portal - [products.iec.ch](http://products.iec.ch)

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

#### Electropedia - [www.electropedia.org](http://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.

# INTERNATIONAL STANDARD



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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.260.20

ISBN 978-2-8322-6271-9

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

## 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<br>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<br>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 connections.....                                      | 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 wires .....   | 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<br>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<br>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<br>complying with Table 7 .....           | 207 |
| Figure I.2 – Tests for enclosures or parts of enclosures for separation distances<br>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 $\leq 40\text{ }^{\circ}\text{C}$ .....       | 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.

The significance of changes between IEC 60079-11, Edition 7 (2023) and IEC 60079-11, Edition 6 (2011 + Corrigendum 1 (2012)) are as listed below:

| Explanation of the significance of changes  | Clause          | Type                        |           |                         |
|---|-----------------|-----------------------------|-----------|-------------------------|
|   |                 | Minor and editorial changes | Extension | Major technical changes |
| A significant number of editorial changes including re-structuring of sections. These are too numerous to list in this table.   | All             | X                           |           |                         |
| Protection of catalytic elements for Group IIC or Group IIB + H <sub>2</sub> excluded from the scope of the standard.   | 1<br>7.14.2     |                             |           | C2                      |
| Extension, with requirements, of ambient pressure down to 60 kPa.   | 1<br>6.5.6.1    |                             | B1        |                         |
| Modification to Table 1 showing Clause 14 of IEC 60079-0 as 'Applies'. This does not affect the technical requirements.   | 1               | X                           |           |                         |
| Definitions removed as they are now in IEC 60079-0.<br>(References are from Ed.6)<br>3.2 coating<br>3.3 conformal coating<br>3.7.1 countable fault<br>3.7.3 non-countable fault<br>3.18 recurring peak voltage<br>3.20 encapsulation<br>3.21 casting<br>3.23 galvanic isolation | 3               | X                           |           |                         |
| Definitions removed as they are no longer considered necessary.<br>(References are from Ed.6)<br>3.7.2 fault<br>3.12 Infallible separation  | 3               | X                           |           |                         |
| Diode safety barriers no longer refers to devices that provide galvanic isolation.  | 3.1.37<br>7.7.5 |                             | X         |                         |
| Intrinsic safety parameters and $U_m$ can have brief transients above the stated values, and these do not need to be taken into account.  | 3.1.9<br>7.7.3  | X                           |           |                         |
| New definition – spark test apparatus.  | 3.1.14          | X                           |           |                         |
| New definition – electrochemical capacitor.   | 3.1.15          |                             | X         |                         |
| New definition – transient rating.  | 3.1.16.1        |                             | X         |                         |
| New definition – transient energy (previously let-through energy).  | 3.1.16.2        | X                           |           |                         |
| New definition – non-hazardous area accessory.  | 3.1.17          | X                           |           |                         |
| Clarification that it is not a requirement of this standard that conformance to industrial standards be verified.   | 5.1             | X                           |           |                         |
| Clarification of conditions for the assessment added.   | 5.2.1           | X                           |           |                         |
| Clarification relating to the application of service temperatures.  | 5.2.1 g)        |                             |           | C1                      |
| Statements that Level of Protection "ia" and "ib" requirements are always sufficient for Level of Protection "ic".  | 5.2.3           |                             | X         |                         |

| Explanation of the significance of changes   | Clause                                    | Type                        |           |                         |
|--|---|-----------------------------|-----------|-------------------------|
|  |   | Minor and editorial changes | Extension | Major technical changes |
| For Level of Protection "ic", faults are only considered for spark ignition assessment and the determination of $U_o$ , $I_o$ , $L_i$ , $C_i$ and $L_i/R_i$ . A short circuit fault, and subsequent component faults arising, are now termed non-countable faults. | 5.2.4<br>6.5.4.3<br>6.5.4.4<br>6.5.4.5    |                             |           | C3                      |
| For Level of Protection "ic", the types of components on which intrinsic safety depends are limited.   | 5.2.4                                     |                             | X         |                         |
| Clarification of the requirements for non-shock hazard equipment or systems (for example SELV / PELV) for declaration of $U_m$ .   | 5.2.5<br>12.1 c)                          | A1                          |           |                         |
| Clarification of where spark ignition assessment should and should not be applied.   | 5.3.1                                     | X                           |           |                         |
| Clarification that spark ignition assessment may be performed on a representative circuit.   | 5.3.1<br>9.1.1                            | X                           |           |                         |
| Spark ignition assessment at normal ambient is suitable for service temperatures between -60 °C and 100 °C.  | 5.3.1                                     |                             | X         |                         |
| Spark ignition testing of mains apparatus is at $U_m$ rather than 110 % of the mains nominal voltage.  | 5.3.4.2 d)                                | X                           |           |                         |
| Annex G added as option for spark ignition assessment.   | 5.3.4.1<br>5.3.4.2<br>9.2.6 c)<br>Annex G |                             | X         |                         |
| Clarification of the requirements for circuits with controlled semiconductor limitation, including need to consider both steady state and transient spark ignition compliance for circuits with controlled semiconductor limitation.                               | 5.3.6<br>Annex D                          |                             |           | C4                      |
| The exclusion of the IEC 60079-0 10 % safety margin on voltage for thermal ignition assessment extended to Groups I and II.  | 5.4.1                                     |                             | X         |                         |
| The 1,3 W limit for T4 for tracks on a printed circuit board now only applies to 40 °C ambient.  | 5.4.1                                     |                             |           | C5                      |
| The 5K and 10K margin required for temperature tests from IEC 60079-0 now apply for Level of Protection "ic".  | 5.4.2                                     |                             |           | C6                      |
| Corrected the formula for thermal assessment of wires.   | 5.4.3                                     |                             |           | C7                      |
| Clarified that only circuit board tracks exposed to the explosive atmosphere require temperature classification.   | 5.4.4                                     | X                           |           |                         |
| Added a note identifying examples of available data for determining temperature rise in PCB tracks (From IPC-2221 and IPC-2152).   | 5.4.4                                     | X                           |           |                         |
| Clarified which dimensions can be reduced by manufacturer's tolerance (track width, board thickness, and conductor thickness).   | 5.4.4                                     | X                           |           |                         |
| Clarified the use of Table 4 by introducing reduction factors for board thickness, number of layers, copper thickness, track under component, and ambient temperature.   | 5.4.4                                     |                             | X         |                         |
| Added allowance for linear interpolation of allowed current, track width, track thickness, ambient temperature, and board thickness.   | 5.4.4                                     |                             | X         |                         |
| Extrapolation of Table 4 is prohibited.  | 5.4.4                                     |                             |           | C1                      |
| Reduced the default board thickness for application of Table 4 from 1,6 mm to 1,55 mm to reflect industry standard.  | 5.4.4                                     |                             | X         |                         |

|   |                              | Type                        |           |                         |
|---|------------------------------|-----------------------------|-----------|-------------------------|
| Explanation of the significance of changes  | Clause                       | Minor and editorial changes | Extension | Major technical changes |
| Clarified that the track under component reduction factor only applies if the portion of the track underneath the component is greater than 10 mm.  | 5.4.4                        |                             | X         |                         |
| Use of the 1,3 W limit for thermal ignition compliance for Group III extended to include Group I.   | 5.4.5                        |                             | X         |                         |
| Board thickness, copper thickness and ambient temperature factors extended in use of Table 4.   | 5.4.4                        |                             | X         |                         |
| Enclosure requirement for Groups IIIA and IIIB aligned with Group I and Group II.   | 6.2.1                        |                             | X         |                         |
| Clarification that the IEC 60079-0 enclosure requirements apply for Group IIIC equipment with separations according to Table 7 (Ed 6 Table 5) that are reliant on an enclosure providing IP5X.  | 6.2.4 a)1)                   |                             |           | C1                      |
| Requirement for a Specific Condition of Use added when use of reduced separations is reliant on an enclosure providing IP54.  | 6.2.5.1                      |                             |           | C8                      |
| Plugs and sockets can comply with reduced separation requirements.  | 6.3.3                        |                             | X         |                         |
| Use of an enclosure to protect battery charging connections from spark ignition (Ed.6 clause 7.4.9) extended to include all non-hazardous area connection facilities.   | 6.3.5.2                      |                             | X         |                         |
| It is no longer necessary to define $U_m$ for the connection from non-hazardous area connection facilities to accessories listed in the certificate provided the accessory is suitably marked and listed in the instructions.   | 6.3.5.3<br>11.1.5<br>12.1 j) |                             | X         |                         |
| It is no longer necessary to assess a non-hazardous area accessory in accordance with this standard.  | 6.3.5.3                      |                             | X         |                         |
| Clarification that charging of cells and batteries in the non-hazardous area has to be within the limits specified by their manufacturer, and IEC 60079-0.  | 6.3.5.3                      | X                           |           |                         |
| Conductors, connectors and PCB tracks have to be suitably rated for their failure to be a countable fault.  | 6.4.1                        |                             |           | C9                      |
| It is now a stated requirement that circuits remain intrinsically safe after disconnection of a connector.  | 6.4.1                        |                             |           | C1                      |
| It is now a requirement that infallible connections remain capable of carrying the current following considered fault disconnections.   | 6.4.2.2<br>6.4.2.3           |                             |           | C10                     |
| Infallible PCB connection achieved with two 1 mm wide tracks now have copper thickness requirements.  | 6.4.2.4                      |                             |           | C11                     |
| The options for infallible PCB connections have been extended.  | 6.4.2.4                      |                             | B2        |                         |
| Clarification that connections complying with IEC 60079-7 Level of Protection "eb" can be considered infallible.  | 6.4.2.5                      | X                           |           |                         |
| Clarification that insulation of component packaging cannot be relied upon for separation of conductive parts unless it is specified by the component manufacturer, except for shorts to its solder pads where they are similar to the recommendations of the component manufacturer. | 6.5.1                        | X                           |           |                         |
| Alternate spacing requirements from the previous edition Annex F have been transferred to the main body of this document.   |                              | A2                          |           |                         |
| Specific Condition of Use only required for Overvoltage Category (OVC) I/II when using Table 8 – Reduced separations.   | 6.5.3.2                      |                             | X         |                         |
| Dielectric strength requirements have been clarified in Table 8 – Reduced separations.  | 6.5.3.2                      |                             |           | C12                     |

| Explanation of the significance of changes   | Clause  | Type                        |           |                         |
|--|---|-----------------------------|-----------|-------------------------|
|  |   | Minor and editorial changes | Extension | Major technical changes |
| Specific Condition of Use required when OVC II/I is required for mains apparatus when using Table 9 – Reduced separations for Level of Protection "ic".      | 6.5.3.3   |                             |           | C13                     |
| Table 8 – Reduced separations is derived from Ed.6 Table F.1 but with additional requirements.   | 6.5.3.2   |                             | X         |                         |
| Routine tests when using Table 9 – Reduced separations for Level of Protection "ic" no longer have to be performed at the most onerous ambient condition.    | 6.5.3.3<br>b)6.5.3.2                            |                             | X         |                         |
| Table 9 – Reduced separations for Level of Protection "ic" is derived from Ed.6 Table F.2 but with additional requirements.                                  | 6.5.3.3   |                             | X         |                         |
| Additional options for infallible separations when exposing connection facilities.   | 6.5.4.2   |                             | X         |                         |
| Separations tables clarify that the voltages do not need to include non-repetitive transients.   | Table 7<br>Table 8<br>Table 9                   | X                           |           |                         |
| Determination of type and routine testing required when using reduced separations tables.  | Table 8<br>6.5.6.2<br>6.5.6.3<br>6.5.6.5<br>9.7 |                             |           | C14                     |
| Additional separation distance options.  | Table 8<br>Table 9                              |                             | X         |                         |
| Dielectric strength test is no longer required for all separations through casting compound and solid insulation.  | 6.5.6.2<br>6.5.6.3                              |                             | X         |                         |
| When Comparative Tracking Index (CTI) Is unknown, a CTI of 100 may be assumed, and some materials are identified as non-tracking.                            | 6.5.6.4   |                             | X         |                         |
| Extended and clarified requirements for assessing creepage distances.  | 6.5.6.4   |                             | X         |                         |
| Two coats of conformal coating no longer required when spraying.   | 6.5.6.5   |                             | X         |                         |
| Consideration of composite separations extended to reduced distances tables.   | 6.5.7   |                             | X         |                         |
| Metal parts used for separation no longer have to be earthed.  | 6.5.9   |                             | X         |                         |
| Where metal parts connected to the frame or earth are used to separate two circuits, a Specific Condition of Use is now required.                            | 6.5.9.1   |                             |           | C15                     |
| Clarification that separation by metal parts requires infallible connection.   | 6.5.9.1   |                             |           | C1                      |
| Relaxation of requirements for non-metallic insulating partitions for Level of Protection "ic".  | 6.5.10  |                             | X         |                         |
| Added requirements for insulation between internal wiring of separate intrinsically safe circuits.   | 6.5.11.3  |                             | X         |                         |
| Encapsulation requirements have been separated and extended according to the purpose of the encapsulation.   | 6.6   |                             | X         |                         |
| Routine verification of encapsulation added.   | 6.6.1<br>10.4                                   |                             |           | C16                     |
| The specified COT for encapsulation shall not be exceeded in normal operation. Tighter requirements for damage to compound for temperature greater than COT. | 6.6.1 a)  |                             |           | C17                     |



| Explanation of the significance of changes   | Clause                | Type                        |           |                         |
|--|-----------------------|-----------------------------|-----------|-------------------------|
|  |                       | Minor and editorial changes | Extension | Major technical changes |
| Free space within encapsulation other than within components is now permitted.   | 6.6.1<br>6.6.7        |                             | X         |                         |
| Requirements for specification of coating, encapsulation and moulding materials.   | 6.7                   |                             |           | C18                     |
| Components used to protect against polarity reversal have to be rated to 7.1.  | 6.8                   |                             |           | C1                      |
| It is now stated that there are circumstances where 2/3 <sup>rd</sup> rating for all three of voltage, current and power are not applicable for Levels of Protection "ia" and "ib".    | 7.1                   | X                           |           |                         |
| Power rating for Level of Protection "ic" does not require a 1,5 safety factor following the application of faults.  | 7.1                   |                             | X         |                         |
| Components for Level of Protection "ic" are considered to fail if they are not within their manufacturer's rating following the application of faults.                                 | 7.1                   |                             |           | C19                     |
| Clarification of the application of manufacturing variations added.  | 7.3                   | X                           |           |                         |
| Resistors of types not listed (film, wire wound and printed) cannot now be considered to fail as a countable fault, nor to limit their own temperature.                                | 7.4.2                 |                             |           | C20                     |
| Clarified that the voltage rating to which the safety factor is applied is that of the resistor series, and not that based on the resistance.  | 7.4.2                 | X                           |           |                         |
| Clarification of the power rating of resistors in series with supercapacitors.   | 7.4.2                 | X                           |           |                         |
| Cold resistance of a fuse, filament of a bulb or infra-red source is assessed at the service temperature rather than the ambient temperature.  | 7.4.2                 |                             |           | C21                     |
| The filament of an infra-red sensor can be used as a resistor for limitation.  | 7.4.2                 |                             | X         |                         |
| Clarification that self-heating of capacitors need not be considered.  | 7.5.1                 |                             | X         |                         |
| An arrangement of two series blocking capacitors need have only half of the infallible separation across each when using Table 7 and Table 9 (this was already permitted for Table 8). | 7.5.3                 |                             | X         |                         |
| Clarification of the failure modes for inductors and transformers.   | 7.6.1<br>7.7<br>7.8.1 | X                           |           |                         |
| References to IEC 60317 updated.   | 7.6.3                 | X                           |           |                         |
| Added requirements and tests for common mode chokes which provides allowances to consider only the leakage inductance of common mode chokes, or the inductance of only one coil.       | 7.6.5<br>9.15         |                             | X         |                         |
| Clarification that assessment of semiconductors cannot be based on failure rates.  | 7.7.1                 |                             |           | C1                      |
| An enhanced voltage generated by an integrated circuit does not need to be considered as being present on other connected pins.  | 7.7.1 c)              |                             | X         |                         |
| Added an allowance for low complexity semiconductors to avoid being considered to fail so as to dissipate maximum power.   | 7.7.1.d)2)            |                             | X         |                         |
| Transient rating of semiconductors only applied to transients caused by current limitation.  | 7.7.3                 |                             | X         |                         |

| Explanation of the significance of changes   | Clause          | Type                        |           |                         |
|--|-----------------|-----------------------------|-----------|-------------------------|
|  |                 | Minor and editorial changes | Extension | Major technical changes |
| Clarification that a safety factor of 1,0 is required when assessing the transient power rating of a semiconductor on which intrinsic safety depends.  | 7.7.3           | X                           |           |                         |
| For Level of Protection "ic", transient rating of semiconductors is only necessary for diode safety barriers.  | 7.7.3           |                             | X         |                         |
| Where two diodes are used in a safety shunt for Level of Protection "ia", the failure of only a single diode has been extended to the failure of a single shunt path. This means that the tracking from the diode to reference voltages (for example, ground) no longer have to be infallible. | 7.7.6           |                             | X         |                         |
| Controlled semiconductor current limitation is permitted for Level of Protection "ia".   | 7.7.7           |                             | X         |                         |
| Clarification of the requirements for programmable components.   | 7.7.8           |                             |           | C1                      |
| Statement that transformers need not be considered to increase the voltage or current beyond that defined by their turns ratio.  | 7.8.1           | X                           |           |                         |
| Table 17 extended with a 10 A column.  | 7.8.3           |                             | X         |                         |
| Foil / screen thickness for 10 A added.  | 7.8.3           |                             | X         |                         |
| Clarification that the requirement for mains transformers includes any transformer that is not galvanically isolated from the mains.   | 7.8.4.1         |                             |           | C1                      |
| Reduced requirements for transformers that are galvanically isolated from the mains.   | 7.8.4.2         |                             | X         |                         |
| Clarification of requirements for transformers for Level of Protection "ic".   | 7.8.5<br>9.17.4 | X                           |           |                         |
| Requirements for transformers for Level of Protection "ic" added.  | 7.8.5           |                             |           | C22                     |
| Clarification of the rating requirements for relays.   | 7.9.2           | X                           |           |                         |
| Countable fault separation between the coil and contacts of a relay is no longer permitted.  | 7.9.2 a)        |                             |           | C23                     |
| Addition of option for relays depending on reduced separation distances internally to comply with IEC 61810-1.   | 7.9.2           |                             | X         |                         |
| Relays in Level of Protection "ic" need only comply with the relevant industrial standards.  | 7.9.2           |                             | X         |                         |
| Clarified that IEC 60079-28 does not apply to self-contained optical isolators.  | 7.10.1          | X                           |           |                         |
| Addition of options for non-optical signal isolators.  | 7.10.2          |                             | X         |                         |
| Clarified that a single fuse is sufficient.  | 7.11            | X                           |           |                         |
| Clarification that the cold resistance of a fuse cannot be used to limit the breaking current.   | 7.11            |                             |           | C1                      |
| A fuse in Level of Protection "ic" shall be considered an ignition risk if its opening is an expected occurrence.  | 7.11            |                             |           | C24                     |
| Clarification that the breaking capacity of fuses connected to $U_m$ may be less than 1 500 A provided that the maximum prospective current is stated in the instructions.   | 7.11<br>12.1 j) |                             |           | C25                     |
| Cells which may explode no longer require a statement from the manufacturer of the cell that they are safe for use in any particular apparatus.  | 7.12.1          |                             | X         |                         |
| Clarification that temperature rise and electrolyte leakage should be considered for cells.  | 7.12.1          |                             |           | C1                      |

|  |                | Type                        |           |                         |
|--|----------------|-----------------------------|-----------|-------------------------|
| Explanation of the significance of changes   | Clause         | Minor and editorial changes | Extension | Major technical changes |
| Clarification that short circuit of a single cell is considered a non-countable fault.   | 7.12.1         |                             |           | C1                      |
| Demonstration of the concentration of hydrogen can come from the manufacturer, rather than the manufacturer of the battery.                                | 7.12.4         |                             | X         |                         |
| Containers for sealed cells and batteries no longer need the pressure test of 9.14.4.  | 7.12.4         |                             | X         |                         |
| Clarification of conditions for determining cell voltages  | 7.12.5         | X                           |           |                         |
| Clarified that the requirements only apply to replaceable batteries.   | 7.12.8         | X                           |           |                         |
| Crystal oscillators are excluded from the requirements for piezoelectric devices, and there are extended requirements for Level of Protection "ic".        | 7.13           |                             | X         |                         |
| Clarified that thermal assessment of catalytic sensors shall take into account heating due to the catalytic reaction.                                      | 7.14.2         |                             |           | C1                      |
| Clarification that supercapacitors shall be treated as batteries with a limited capacity but without the ability to limit their own voltage.               | 7.15<br>9.14   |                             |           | C26                     |
| Requirements and tests for thermal devices added, including PTCs.  | 7.16<br>9.12   |                             |           | C27                     |
| Clarification that mechanical switches do not require thermal ignition assessment.   | 7.17           | X                           |           |                         |
| Clarification that the protective diodes in diode safety barriers shall be protected by a fuse or resistor(s) and not controlled semiconductor limitation. | 8.1.1          | X                           |           |                         |
| Additional options for earth facilities for diode safety barriers.   | 8.1.2.2        |                             | X         |                         |
| Requirement for 110 % of the mains supply voltage when applying the spark test apparatus removed as the conditions for test are specified in 5.2.          | 9.1.1          |                             | X         |                         |
| Clarified that all circuits (not just capacitive) need to have time to recover where applicable during spark testing.                                      | 9.1.2          | X                           |           |                         |
| Added allowance for slowing the spark test apparatus down when removing wires is not sufficient to allow rest of the circuit under test.                   | 9.1.2          |                             | X         |                         |
| Clarified that the effect of temperature on an inductor's resistance shall be taken into account during spark testing.                                     | 9.1.2          |                             |           | C1                      |
| Clarified that the sensitivity of the spark test apparatus may be checked if there is an unexpected failure.   | 9.1.2          | X                           |           |                         |
| Minimum ignition current for calibration of the spark test apparatus added.  | 9.1.3          | X                           |           |                         |
| Added formula option for reducing effective capacitance with a resistor.   | 9.2.3.3        |                             | X         |                         |
| Clarification that consideration of the combination of inductance and capacitance is required internal to equipment and not just at connection facilities. | 9.2.6          | X                           |           |                         |
| An assessment that demonstrates that the safety factor is maintained with a combination of both inductance and capacitance is allowed.                     | 9.2.6 b)       |                             | X         |                         |
| Where parameters are specified for combined lumped inductance and capacitance, that shall be stated in the certificate or documentation.                   | 9.2.6          | X                           |           |                         |
| 30 N test for casting compound and partitions are not applicable for Level of Protection "ic".   | 9.4.1<br>9.4.3 |                             | X         |                         |

| Explanation of the significance of changes   | Clause                | Type                        |           |                         |
|--|-----------------------|-----------------------------|-----------|-------------------------|
|  |                       | Minor and editorial changes | Extension | Major technical changes |
| Test temperature for immersion in water for encapsulated fuses has been lowered by 2 °C for compatibility with other testing.  | 9.4.2                 | X                           |           |                         |
| Parameters for loosely specified components shall be determined taking into account the service temperature, not just the ambient temperature.   | 9.13                  | X                           |           |                         |
| Clarification and modification of the tests for optical isolators.   | 9.10                  |                             | X         |                         |
| Clarified that tests on piezoelectric devices need be performed on only a single sample, unless that sample is damaged during the testing.   | 9.11                  | X                           |           |                         |
| Clarified that primary cells shall be unused and limiting devices shall be removed for the electrolyte leakage test.   | 9.14.1                | X                           |           |                         |
| Clarified that the current shall be continuous when discharging during the tests.  | 9.14.1                |                             |           | C1                      |
| Cells that have essential features that limit their current may be used for Level of Protection "ia".  | 9.14.1                |                             | X         |                         |
| Cells that explode or catch fire during short circuit test shall not be used for Levels of Protection "ia" and "ib".   | 9.14.1                | X                           |           |                         |
| Electrolyte leakage and surface temperature test requirements for cells and batteries modified to cover the number of samples tested, the test temperature, and testing with dust layers.  | 9.14.1                |                             |           | C28                     |
| Added option to conduct short circuit until discharge testing for Level of Protection "ic" to establish compliance with the electrolyte leakage requirement.   | 9.14.2 a)             |                             | X         |                         |
| Added alternative assessment of damage to encapsulation from leaked electrolyte.   | 9.14.2                |                             | X         |                         |
| Spark ignition of batteries may be carried out following current limitation where separation is maintained.  | 9.14.3.2              |                             | X         |                         |
| Requirement added to consider the spark ignition risk of single lithium cells of less than 4,5 V with high short circuit current.  | 9.14.3.2              |                             |           | C29                     |
| For single cells, it is sufficient to measure the temperature in the middle of the cell rather than having to locate the highest temperature point.  | 9.14.3.3              |                             | X         |                         |
| For thermal ignition assessment of cells and batteries with Level of Protection "ib", added an alternative test for lithium-ion rechargeable cells where it is not possible to obtain samples with current limiting devices disabled. There is an assumption that these cells will leak electrolyte so 7.12.3 applies. | 9.14.3.3 b)<br>9.14.2 |                             | X         |                         |
| Where limiting devices are removed from a cell for testing, it is no longer necessary to also test with 10 samples with the limiting devices still in place.   | 9.14.3.3              |                             | X         |                         |
| Only a single sample need be tested for thermal ignition compliance testing of cells or batteries for Level of Protection "ic".  | 9.14.3.3 c)           |                             | X         |                         |
| Transient test for diode safety barriers and safety shunts has been extended to include controlled semiconductor current limitation.   | 9.16                  |                             | X         |                         |
| Clarify that transformer dielectric strength test is a test at room temperature.   | 9.17.1                | X                           |           |                         |
| Reduced testing requirements for transformers that are galvanically isolated from the mains.   | 9.17.2                |                             | X         |                         |

|  |              | Type                        |           |                         |
|--|--------------|-----------------------------|-----------|-------------------------|
| Explanation of the significance of changes   | Clause       | Minor and editorial changes | Extension | Major technical changes |
| Transformer windings requiring galvanic separation between different intrinsically safe circuits are to be tested for a dielectric strength of $2U$ if that is greater than 500 V.         | 10.3.1       |                             |           | C30                     |
| Transformers for Level of Protection "ic" shall be routine tested where there is no applicable industrial standard, or the applicable industrial standard does not specify a routine test. | 10.2.2       |                             |           | C31                     |
| Marking of IP rating no longer required as this is now a Specific Condition of Use.  | 11           |                             | X         |                         |
| Flowchart for testing of enclosures added.   | Annex I      | X                           |           |                         |
| List of voltage limiting techniques has been deleted.  | former 8.7.3 | A3                          |           |                         |
| Requirements for handlights and caplights removed as these are covered elsewhere (including in other standards).   | former 9.3   | 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.

## 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  $U_m$  is to be applied across galvanic isolations.
- A2 The Annex for 'Alternative separation distances for assembled printed circuit boards and separation of components' in the previous edition is now incorporated in the main text and the alternate spacing tables are now Table 8 and Table 9.
- A3 Except for c) batteries for which there is no longer a suggestion that they can be used as voltage limiting shunt devices. Nonetheless, there is no intent to change their use as such.
- B1 Apparatus may be used at lower atmospheric pressure than the default 80 kPa specified in IEC 60079-0 with additional requirements such as an increase in clearance for associated apparatus operated at less than 80 kPa.
- B2 The values used were based on those in IPC-6012B and tolerances have been taken into account.
- C1 It is recognized that the clarified requirements were, in many cases, already applied. The change is to ensure that they are uniformly and consistently applied.
- C2 Catalytic sensors have been demonstrated to auto-ignite hydrogen without electrical stimulus so are not suitable for protection by intrinsic safety.
- C3 Failure of separations and subsequent failure of components are considered non-countable faults for "ic". This is expected to be a change in terminology only but is highlighted here as it could change the assessment methodology in some instances.
- C4 The steady state maximum voltage and current presents a different spark ignition risk than a transient. A transient is where either of these (voltage or current) is exceeded. Therefore, steady states and transients need to be considered separately. The Annex on transients has been revised.
- C5 Modified to align with assessment for wires.
- C6 Since thermal assessment for Level of Protection "ic" is substantively under normal operation, the margin is considered a required safety factor.
- C7 The formula used for calculating the temperature rise of wiring has been corrected.
- C8 Where reduced separation distances rely on an enclosure providing an ingress protection of IP54, and cable glands, thread adapters and blanking elements are necessary to complete the enclosure to maintain the Ingress Protection (IP) rating these also need to comply with IEC 60079-0.
- C9 Conductors, connectors and PCB tracks have to be suitably rated for their failure to be a countable fault.
- C10 It is now a requirement that infallible connections remain capable of carrying the current following considered fault disconnections.
- C11 Infallible PCB connection achieved with two 1 mm wide tracks now have copper thickness requirements.
- C12 The safety of reduced separations relies on a suitable dielectric strength for the insulating materials, and these have been added to Table 8.
- C13 A Specific Condition of Use is required when Over Voltage Category II/I is required for mains apparatus when using Table 9 – Reduced separations for Level of Protection "ic".
- C14 The previous edition made references to the tests in IEC 60664-1 and IEC 60664-3, however, it did not state which tests applied. This edition clarifies which tests apply by including them in the text.
- C15 This is to be compatible with the Specific Condition of Use already required where insulation between an intrinsically safe circuit and the frame or earth does not meet the dielectric strength requirements.
- C16 A routine inspection requirement was added for encapsulated parts to ensure that the application of the encapsulant is acceptable during manufacture.

- C17 The Continuous Operating Temperature requirements are a modification of those specified in IEC 60079-0. When temperatures higher than the COT are possible, there must be no damage internally or externally, whereas for Ed.6 the requirement was no visible damage.
- C18 The specifications required for coating, encapsulation and moulding are a modification of those detailed in IEC 60079-0.
- C19 Ed.6 did not state how to consider failure of components where the application of failure of separation resulted in them being operated outside of their manufacturer's specification. This is considered necessary, but for spark ignition only.
- C20 This is a consequence of the re-organisation of the requirements for components.
- C21 The cold resistance was previously permitted to be measured at the minimum ambient temperature.
- C22 It was recognised that when the requirements for Ex nL were transferred into IEC 60079-11 as Ex ic not all components were addressed. This meant that an Ex ia transformer construction was required for Ex ic equipment.
- C23 Countable fault separation between the coil and contacts of a relay is no longer permitted.
- C24 A fuse in Level of Protection "ic" shall be considered an ignition risk if its opening is an expected occurrence.
- C25 Fuses connected to the mains supply are permitted to have a breaking capacity of less than 1 500 A. However, it is necessary that users and installers are made aware when this is the case and therefore it is a requirement to include the maximum prospective current in the instructions.
- C26 Requirements for supercapacitors added.
- C27 Requirements for the use of thermal devices (PTCs etc.) have been added.
- C28 Electrolyte leakage, surface temperature test and test under dust requirements for cells, batteries and supercapacitors modified, increasing the number of samples tested and defining the temperature at which the tests are conducted.
- C29 Spark ignition has been demonstrated during short circuit of some lithium cells.
- C30 Routine tests for transformers with primary and secondary windings in an intrinsically safe circuit changed.
- C31 Addition of a specific routine test for transformers used in Ex ic circuits.

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

| Draft        | Report on voting |
|--------------|------------------|
| 31G/352/FDIS | 31G/359/RVD      |

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

This document supplements and modifies the general requirements of IEC 60079-0, except as indicated in Table 1.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

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.

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



## EXPLOSIVE ATMOSPHERES –

### Part 11: Equipment protection by intrinsic safety "i"

#### 1 Scope

This part of IEC 60079 specifies the construction and testing of intrinsically safe apparatus intended for use in explosive atmospheres, and for associated apparatus which is intended for connection to intrinsically safe circuits which enter such atmospheres.

This Type of Protection is applicable to electrical equipment in which the electrical circuits themselves are incapable of causing ignition of a surrounding explosive atmosphere. This includes electrical equipment which contains circuits that are intrinsically safe only under certain conditions, for example under battery supply with mains supply removed.

This document is also applicable to electrical equipment or parts of electrical equipment located outside the explosive atmosphere or protected by another Type of Protection listed in IEC 60079-0, where the intrinsic safety of the electrical circuits in the explosive atmosphere may depend upon the design and construction of such electrical equipment or parts of such electrical equipment. The electrical circuits exposed to the explosive atmosphere are assessed for use in such atmospheres by applying this document.

This document applies to sensors connected to intrinsically safe circuits but does not apply to the protection of catalytic elements for Group IIC or Group IIB + H<sub>2</sub>.

This document does not apply to Ex Equipment cable glands.

The requirements for intrinsically safe systems are provided in IEC 60079-25.

This document supplements and modifies the general requirements of IEC 60079-0, except as indicated in Table 1. Where a requirement of this document conflicts with a requirement of IEC 60079-0, the requirement of this document takes precedence.

Unless otherwise stated, the requirements in this document are applicable to both intrinsically safe apparatus and associated apparatus, and the generic term "apparatus" is used throughout the standard.

As this document applies only to electrical equipment, the term "equipment" used in the standard always means "electrical equipment".

This document applies to apparatus for use under the atmospheric conditions of IEC 60079-0 with additional requirements for use at extended atmospheric pressures in the range from 60 kPa (0,6 bar), up to 110 kPa (1,1 bar).

**Table 1 – Applicability of specific clauses of IEC 60079-0**

| Clause or subclause of IEC 60079-0 |                                 |  | IEC 60079-0 clause application to IEC 60079-11 |   |   |
|------------------------------------|---------------------------------|--|--|---|---|
|                                    |                                 |  | Intrinsically safe apparatus                   |   | Associated apparatus                    |
| Ed.6<br>(2011)<br>(informative)    | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)                                 | Group I and<br>Group II                        | Group III                               |   |
| 3                                  | 3                               | Terms and definitions  | Applies  | Applies                                 | Applies                                 |
| 4                                  | 4                               | Equipment grouping   | Applies  | Applies                                 | Applies                                 |
| 5                                  | 5                               | Temperatures   |  |   |   |
| 5.1                                | 5.1                             | Environmental influences   | Applies  | Applies                                 | Applies                                 |
| 5.2                                | 5.2                             | Service temperature  | Applies  | Applies                                 | Applies                                 |
| 5.3                                | 5.3                             | Maximum surface temperature  | Applies  | Applies                                 | Excluded                                |
| 6                                  | 6                               | Requirements for all electrical apparatus                                  |  |   |   |
| 6.1                                | 6.1                             | General  | Applies  | Applies                                 | Applies                                 |
| 6.2                                | 6.2                             | Mechanical strength  | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| 6.3                                | 6.3                             | Opening times  | Excluded                                       | Excluded                                | Excluded                                |
| 6.4                                | 6.4                             | Circulating currents in enclosures (e.g. of large electric machines)       | Excluded                                       | Excluded                                | Excluded                                |
| 6.5                                | 6.5                             | Gasket retention   | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| 6.6                                | 6.6                             | Electromagnetic and ultrasonic energy radiating equipment                  |  |   |   |
| -                                  | 6.6.1                           | General  | Applies  | Applies                                 | Excluded                                |
| 6.6.1                              | 6.6.2                           | Radio frequency sources  | Applies  | Applies                                 | Excluded                                |
| 6.6.3                              | 6.6.3                           | Ultrasonic sources   | Applies  | Applies                                 | Excluded                                |
| 6.6.2                              | 6.6.4                           | Lasers, luminaires and other non-divergent continuous wave optical sources | Modified                                       | Modified                                | Excluded                                |
| 7                                  | 7                               | Non-metallic enclosures and non-metallic parts of enclosures               |  |   |   |
| 7.1                                | 7.1                             | General  | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| 7.2                                | 7.2                             | Thermal endurance  | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| 7.3                                | 7.3                             | Resistance to ultraviolet light  | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| 7.4                                | 7.4                             | Electrostatic charges on external non-metallic materials                   | Applies  | Applies                                 | Excluded                                |

| Clause or subclause of IEC 60079-0 |                                 |  | IEC 60079-0 clause application to IEC 60079-11 |  |  |
|------------------------------------|---------------------------------|--|--|--|--|
|                                    |                                 |  | Intrinsically safe apparatus                   |  | Associated apparatus                             |
| Ed.6<br>(2011)<br>(informative)    | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)                     | Group I and<br>Group II                        | Group III                                      |  |
| 7.5                                | 7.5                             | Attached external<br>conductive parts                          | Applies  | Applies  | Excluded   |
| 8                                  | 8                               | Metallic enclosures and<br>metallic parts of<br>enclosures     | Applies  | Applies  | Excluded   |
| 9                                  | 9                               | Fasteners  | Excluded                                       | Excluded                                       | Excluded   |
| 10                                 | 10                              | Interlocking devices   | Applies  | Applies  | Excluded   |
| 11                                 | 11                              | Bushings   | Excluded                                       | Excluded                                       | Excluded   |
| 12                                 | -                               | Materials used for<br>cementing                                | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 are<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| -                                  | 12                              | (Reserved for future use)                                      | -  | -  | -  |
| 13                                 | 13                              | Ex Components  | Applies  | Applies  | Applies  |
| 14                                 | 14                              | Connection facilities  |  |  |  |
| 14.1                               | 14.1                            | General  | Applies  | Applies  | Applies  |
| 14.2                               | -                               | Termination compartment  | Applies  | Applies  | Applies  |
| 14.3                               | 14.2                            | Type of Protection   | Applies  | Applies  | Modified   |
| 14.4                               | 14.3                            | Creepage and clearance   | Applies  | Applies  | Applies  |
| 15                                 | 15                              | Connection facilities for<br>earthing or bonding<br>conductors | Excluded                                       | Excluded                                       | Excluded   |
| 16                                 | 16                              | Entries into enclosures  |  |  |  |
| 16.1                               | 16.1                            | General  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.2                               | 16.2                            | Identification of entries                                      | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.3                               | 16.3                            | Cable Glands   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.4                               | 16.4                            | Blanking elements  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.5                               | 16.5                            | Thread adapters  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.6                               | 16.6                            | Temperature at branching<br>point and entry point              | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 16.7                               | 16.7                            | Electrostatic charges of<br>cable sheaths                      | Applies  | Applies  | Applies  |

| Clause or subclause of IEC 60079-0 |                                 |  | IEC 60079-0 clause application to IEC 60079-11 |           |                      |
|------------------------------------|---------------------------------|--|--|-----------|----------------------|
|                                    |                                 |  | Intrinsically safe apparatus                   |           | Associated apparatus |
| Ed.6<br>(2011)<br>(informative)    | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)   | Group I and<br>Group II                        | Group III |                      |
| 17                                 | 17                              | Supplementary requirements for electric machines   | Excluded                                       | Excluded  | Excluded             |
| 18                                 | 18                              | Supplementary requirements for switchgear  | Excluded                                       | Excluded  | Excluded             |
| 19                                 | -                               | Supplementary requirements for fuses   | Excluded                                       | Excluded  | Excluded             |
| -                                  | 19                              | Reserved for future use  | -  | -         | -                    |
| 20                                 | 20                              | Supplementary requirements for external plugs, socket outlets and connectors for field wiring connection | Excluded                                       | Excluded  | Excluded             |
| 21                                 | 21                              | Supplementary requirements for luminaires  | Excluded                                       | Excluded  | Excluded             |
| 22                                 | 22                              | Supplementary requirements for caplights and handlights  |  |           |                      |
| 22.1                               | 22.1                            | Group I caplights  | Applies  | Excluded  | Excluded             |
| 22.2                               | 22.2                            | Group II and Group III caplights and handlights  | Excluded                                       | Excluded  | Excluded             |
| 23                                 | 23                              | Equipment incorporating cells and batteries  |  |           |                      |
| 23.1                               | 23.1                            | General  | Applies  | Applies   | Applies              |
| 23.2                               | 23.2                            | Interconnection of cells to form batteries   | Excluded                                       | Excluded  | Excluded             |
| 23.3                               | 23.3                            | Cell types   | Modified                                       | Modified  | Modified             |
| 23.4                               | 23.4                            | Cells in a battery   | Applies  | Applies   | Applies              |
| 23.5                               | 23.5                            | Ratings of batteries   | Applies  | Applies   | Applies              |
| 23.6                               | 23.6                            | Interchangeability   | Applies  | Applies   | Applies              |
| 23.7                               | 23.7                            | Charging of primary batteries  | Applies  | Applies   | Applies              |
| 23.8                               | 23.8                            | Leakage  | Applies  | Applies   | Applies              |
| 23.9                               | 23.9                            | Connections  | Applies  | Applies   | Applies              |
| 23.10                              | 23.10                           | Orientation  | Applies  | Applies   | Applies              |
| 23.11                              | 23.11                           | Replacement of cells or batteries  | Applies  | Applies   | Applies              |
| 23.12                              | 23.12                           | Replaceable battery pack   | Applies  | Applies   | Applies              |
| 24                                 | 24                              | Documentation  | Applies  | Applies   | Applies              |
| 25                                 | 25                              | Compliance of prototype or sample with documents   | Applies  | Applies   | Applies              |
| 26                                 | 26                              | Type tests   |  |           |                      |
| 26.1                               | 26.1                            | General  | Applies  | Applies   | Applies              |
| 26.2                               | 26.2                            | Test configuration   | Applies  | Applies   | Applies              |
| 26.3                               | 26.3                            | Tests in explosive test mixtures   | Applies  | Applies   | Applies              |

| Clause or subclause of IEC 60079-0 |                                 |  | IEC 60079-0 clause application to IEC 60079-11 |   |  |
|------------------------------------|---------------------------------|--|--|---|--|
|                                    |                                 |  | Intrinsically safe apparatus                   |   | Associated apparatus                             |
| Ed.6<br>(2011)<br>(informative)    | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)                                     | Group I and<br>Group II                        | Group III                                     |  |
| 26.4                               | 26.4                            | Tests of enclosures  |  |   |  |
| 26.4.1                             | 26.4.1                          | Order of tests   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.4.2                             | 26.4.2                          | Resistance to impact   | Excluded except<br>see <sup>a</sup>            | Excluded except<br>see <sup>a</sup>           | Excluded<br>except see <sup>a</sup>              |
| 26.4.3                             | 26.4.3                          | Drop test  | Applies  | Applies                                       | Applies  |
| 26.4.4                             | 26.4.4                          | Acceptance criteria  | Applies  | Applies                                       | Applies  |
| 26.4.5                             | 26.4.5                          | Degree of protection (IP)<br>by enclosures                                     | Applies  | Applies                                       | Applies  |
| 26.5                               | 26.5                            | Thermal tests  |  |   |  |
| 26.5.1                             | 26.5.1                          | Temperature<br>measurement   |  |   |  |
| 26.5.1.1                           | 26.5.1.1                        | General  | Applies  | Applies                                       | Excluded   |
| 26.5.1.2                           | 26.5.1.2                        | Service temperature  | Applies  | Applies                                       | Applies  |
| 26.5.1.3                           | 26.5.1.3                        | Maximum surface<br>temperature   | Modified                                       | Modified                                      | Excluded   |
| 26.5.2                             | 26.5.2                          | Thermal shock test   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.5.3                             | 26.5.3                          | Small component ignition<br>test (Group I and Group<br>II)                     | Applies  | Excluded                                      | Excluded   |
| 26.6                               | 26.6                            | Torque test for bushings   | Excluded                                       | Excluded                                      | Excluded   |
| 26.7                               | 26.7                            | Non-metallic enclosures<br>or non-metallic parts of<br>enclosures              | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.8                               | 26.8                            | Thermal endurance to<br>heat   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.9                               | 26.9                            | Thermal endurance to<br>cold   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.10                              | 26.10                           | Resistance to UV light   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| 26.11                              | 26.11                           | Resistance to chemical<br>agents for Group I<br>equipment                      | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded                                      | Excluded   |
| 26.12                              | 26.12                           | Earth continuity   | Excluded                                       | Excluded                                      | Excluded   |
| 26.13                              | 26.13                           | Surface resistance test of<br>parts of enclosures of<br>non-metallic materials | Applies  | Applies                                       | Excluded   |
| 26.14                              | 26.14                           | Measurement of<br>capacitance  | Applies  | Applies                                       | Excluded   |

| Clause or subclause of IEC 60079-0 |                                 |  | IEC 60079-0 clause application to IEC 60079-11 |   |   |
|------------------------------------|---------------------------------|--|--|---|---|
|                                    |                                 |  | Intrinsically safe apparatus                   |   | Associated apparatus                    |
| Ed.6<br>(2011)<br>(informative)    | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)                             | Group I and<br>Group II                        | Group III                               |   |
| 26.15                              | 26.15                           | Verification of ratings of ventilating fans                            | Excluded                                       | Excluded                                | Excluded                                |
| 26.16                              | 26.16                           | Alternative qualification of elastomeric sealing O-rings               | Excluded except when 6.2.5.1 is applied        | Excluded except when 6.2.5.1 is applied | Excluded except when 6.2.5.1 is applied |
| NR                                 | 26.17                           | Transferred charge test  | Applies  | Excluded                                | Excluded                                |
| 27                                 | 27                              | Routine tests  | Applies  | Applies                                 | Applies                                 |
| 28                                 | 28                              | Manufacturer's responsibility  | Applies <sup>b</sup>                           | Applies <sup>b</sup>                    | Applies                                 |
| 29                                 | 29                              | Marking  |  |   |   |
| 29.1                               | 29.1                            | Applicability  | Applies  | Applies                                 | Applies                                 |
| 29.2                               | 29.2                            | Location   | Applies  | Applies                                 | Applies                                 |
| 29.3                               | 29.3                            | General  | Applies  | Applies                                 | Applies                                 |
| 29.4                               | 29.4                            | Ex marking for explosive gas atmospheres                               | Applies  | Excluded                                | Applies                                 |
| 29.5                               | 29.5                            | Ex marking for explosive dust atmospheres                              | Excluded                                       | Applies                                 | Applies                                 |
| 29.6                               | 29.6                            | Combined types (or levels) of protection                               | Applies  | Applies                                 | Applies                                 |
| 29.7                               | 29.7                            | Multiple types of protection   | Applies  | Applies                                 | Applies                                 |
| 29.8                               | 29.8                            | Ga equipment using two independent Gb types (or levels) of protection  | Applies  | Excluded                                | Excluded                                |
| NR                                 | 29.9                            | Boundary wall  | Applies  | Applies                                 | Excluded                                |
| 29.9                               | 29.10                           | Ex Components  | Applies  | Applies                                 | Applies                                 |
| 29.10                              | 29.11                           | Small Ex Equipment and small Ex Components                             | Applies  | Applies                                 | Applies                                 |
| 29.11                              | 29.12                           | Extremely small equipment and extremely small Ex Components            | Applies  | Applies                                 | Applies                                 |
| 29.12                              | 29.13                           | Warning markings   | Applies  | Applies                                 | Applies                                 |
| 29.13                              | -                               | Alternate marking of Equipment Protection Levels (EPLs)                | Applies  | Applies                                 | Applies                                 |
| 29.13.1                            | -                               | Alternate marking of Type of Protection for explosive gas atmospheres  | Applies  | Excluded                                | Applies                                 |
| 29.13.2                            | -                               | Alternate marking of Type of Protection for explosive dust atmospheres | Excluded                                       | Applies                                 | Applies                                 |
| 29.14                              | 29.14                           | Cells and batteries  | Applies  | Applies                                 | Applies                                 |
| 29.15                              | 29.15                           | Electrical machines operated with a converter                          | Excluded                                       | Excluded                                | Excluded                                |
| 29.16                              | 29.16                           | Examples of marking  | Examples only                                  | Examples only                           | Examples only                           |
| 30                                 | 30                              | Instructions   |  |   |   |
| 30.1                               | 30.1                            | General  | Applies  | Applies                                 | Applies                                 |

| Clause or subclause of IEC 60079-0  |                                 |   | IEC 60079-0 clause application to IEC 60079-11 |   |  |
|---|---------------------------------|---|--|---|--|
|   |                                 |   | Intrinsically safe apparatus                   |   | Associated apparatus                             |
| Ed.6<br>(2011)<br>(informative)   | Ed.7<br>(2017)<br>(informative) | Clause / Subclause<br>title<br>(normative)  | Group I and<br>Group II                        | Group III                                     |  |
| 30.2  | 30.2                            | Cells and batteries   | Applies  | Applies                                       | Applies  |
| 30.3  | 30.3                            | Electric machines   | Excluded                                       | Excluded                                      | Excluded   |
| 30.4  | 30.4                            | Ventilating fans  | Excluded                                       | Excluded                                      | Excluded   |
| -   | 30.5                            | Cable Glands  | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| Annex A   | Annex A                         | Supplementary<br>requirements for cable<br>glands   | Excluded except<br>when 6.2.5.1 is<br>applied  | Excluded except<br>when 6.2.5.1 is<br>applied | Excluded<br>except when<br>6.2.5.1 is<br>applied |
| Annex B   | Annex B                         | Requirements for Ex<br>Components   | Applies  | Applies                                       | Applies  |
| Annex C   | Annex C                         | Example of rig for<br>resistance to impact test   | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| Annex D   | Annex D                         | Electric machines<br>connected to converters  | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| Annex E   | Annex E                         | Temperature evaluation<br>of electric machines  | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| Annex F   | Annex F                         | Guideline flowchart for<br>tests of non-metallic<br>enclosures<br>or non-metallic parts of<br>enclosures (26.4) | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| -   | Annex G                         | Guidance flowchart for<br>tests of cable glands   | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| -   | Annex H                         | Shaft voltages resulting in<br>motor bearing or shaft<br>brush sparking. Discharge<br>energy calculation        | Informative Annex                              | Informative Annex                             | Informative<br>Annex                             |
| Applies – This Clause / Subclause of IEC 60079-0 is applied without change.   |                                 |   |  |   |  |
| Excluded – This Clause / Subclause of IEC 60079-0 does not apply.   |                                 |   |  |   |  |
| Modified – This Clause / Subclause of IEC 60079-0 is modified as detailed in this document.   |                                 |   |  |   |  |
| <p>NOTE 1 The applicable Clauses / Subclauses of IEC 60079-0 are identified by the Clause / Subclause title which is normative. This document was written against the specific requirements of IEC 60079-0:2017 (Ed.7). The Clause / Subclause numbers for the 7<sup>th</sup> and previous edition are shown for information only. This is to enable the general requirements of IEC 60079-0:2011 (Ed.6) to be used where necessary with this part of IEC 60079. Where there were no requirements in the 6<sup>th</sup> edition but there are for the 7<sup>th</sup> edition (indicated by NR against the 6<sup>th</sup> edition only), or where there is a conflict between requirements, the later edition requirements take precedence.</p> <p>NOTE 2 A shaded row in the above table indicates that this is a Clause heading. In cases where the applicability is the same for all the subclauses the 'Applies' or 'Excluded' is listed in the heading row and the subclauses are not expanded. Where the application of the individual sub-clauses may be different, these are expanded in the above table and the applicability for each is listed.</p> <p><sup>a</sup> Excluded except when 6.2.5.1 is applied, or as required by 9.4.1 or 9.11.</p> <p><sup>b</sup> Excluded for simple apparatus. See 3.1.5 and 5.5.</p> |                                 |   |  |   |  |

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

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

IEC 60079-25, *Explosive atmospheres – Part 25: Intrinsically safe electrical systems*

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

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

IEC 60127 (all parts), *Miniature fuses*

IEC 60317-0-1, *Specifications for particular types of winding wires – Part 0-1: General requirements – Enamelled round copper wire*

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

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

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

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

IEC 60747-5-5, *Semiconductor devices – Part 5-5: Optoelectronic devices – Photocouplers*

IEC 60747-17, *Semiconductor devices – Part 17: Magnetic and capacitive coupler for basic and reinforced insulation*

IEC 60851-5, *Winding wires – Test methods – Part 5: Electrical properties*

IEC 61010-1, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61158-2, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*

IEC 61810-1, *Electromechanical elementary relays – Part 1: General and safety requirements*

IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications – Part 2: Lithium systems*

ANSI/UL 248 series, *Low-Voltage Fuses*



ANSI/UL 746E, *Polymeric Materials – Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used In Printed Wiring Boards*

UL 810A, *Standard for Electrochemical Capacitors*

DIN VDE V 0884-11, *Semiconductor devices – Part 11: Magnetic and capacitive coupler for basic and reinforced isolation*

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60079-0 and the following 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>

##### 3.1.1

##### **intrinsic safety "i"**

Type of Protection based on the restriction of electrical energy within equipment and of interconnecting wiring exposed to the explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects

##### 3.1.2

##### **intrinsically safe apparatus**

electrical equipment in which all the circuits are intrinsically safe circuits whilst in the hazardous area

##### 3.1.3

##### **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

[SOURCE: IEC 60050-426:2020, 426-11-03]

##### 3.1.4

##### **intrinsically safe circuit**

circuit, in which any spark or any thermal effect produced under the conditions specified in IEC 60079-11, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive atmosphere

##### 3.1.5

##### **simple apparatus**

electrical component or combination of components of simple construction with well-defined electrical parameters that is compatible with the intrinsic safety of the circuit in which it is used