

**ISA-60079-11 (12.02.01)-2009**

**Supersedes ANSI/ISA-60079-11 (12.02.01)-2002**

# **Explosive Atmospheres – Part 11: Equipment protection by intrinsic safety “i”**

**UNDER AN AGREEMENT WITH THE U.S. NATIONAL  
COMMITTEE OF THE INTERNATIONAL  
ELECTROTECHNICAL COMMISSION (IEC), THIS  
COPY OF AN EXTRACT OR TOTAL IEC PUBLICATION  
IS TO BE USED SOLELY FOR THE PURPOSES OF  
FURTHER DEVELOPMENT OF INTERNATIONAL  
STANDARDS. IT MAY NOT BE OFFERED FOR  
FURTHER REPRODUCTION OR FOR SALE. THE  
COPYRIGHT RESTS WITH THE IEC, GENEVA,  
SWITZERLAND.**

**Draft 5 – October 2008**

## Commitment for Amendments

This standard is issued jointly by the International Society of Automation (ISA) and Underwriters Laboratories Incorporated (UL). Comments or proposals for revisions on any part of the standard may be submitted to ISA or UL at any time. Revisions to this standard will be made only after processing according to the standards development procedures of ISA and UL. *ISA and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue.*

---

ISBN

Copyright © 2009

By ISA

These materials are subject to copyright claims of IEC, ANSI, and ISA. All rights reserved. Not for resale. Printed in the United States of America. No part of this publication may be reproduced in any form, including an electronic retrieval system, without the prior written permission of ISA. All requests pertaining to this standard should be submitted to ISA.

---

Copyright © 2009 Underwriters Laboratories Inc.

UL's Standards for Safety are copyrighted by UL. Neither a printed nor electronic copy of a Standard should be altered in any way. All of UL's Standards and all copyrights, ownerships, and rights regarding those Standards shall remain the sole and exclusive property of UL.

This ANSI/UL Standard for Safety consists of the Fifth edition is under continuous maintenance, whereby each revision is ANSI approved upon publication.

The most recent designation of ANSI/UL 60079-11 as a Reaffirmed American National Standard (ANS) occurred on March 7, 2007.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at <http://csds.ul.com>.

To purchase UL Standards, visit Comm 2000 at [http://www.comm-2000.com/help/how\\_to\\_order.aspx](http://www.comm-2000.com/help/how_to_order.aspx) or call toll-free 1-888-853-3503.

**ISA**  
**ISA-60079-11**  
**5th Edition**

**Underwriters Laboratories Inc.**  
**UL 60079-11**  
**5th Edition**



**Explosive Atmospheres – Part 11: Equipment protection by  
intrinsic safety “i”**

This page intentionally left blank.

## General Notes

This is the common ISA and UL Standard for Explosive Atmospheres – Part 11: Equipment Protection by Intrinsic Safety “i”. It is the Fifth edition of ISA-60079–11 and the Fifth edition of UL 60079-11. This document is a modification of the IEC document and includes US deviations encompassing both additions and deletions of information.

ISA 60079-11 and UL 60079-11 contain identical requirements, and identical publication dates. The presentation and format of the standards material may differ between the two published standards.

This common Standard was prepared by The International Society of Automation (ISA) and Underwriters Laboratories Inc. (UL).

NOTE Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.

### Level of harmonization

This standard adopts the IEC text with deviations.

The requirements are presented in different formats. The ISA version of the standard illustrates the national differences from the IEC text through the use of legislative text (strike-out and underline). The UL version of the standard illustrates national differences immediately following the IEC text. National differences between the UL version and the ISA version shall be word for word except for editorial changes.

### Interpretations

The interpretation by the SDO of an identical or equivalent standard shall be based on the literal text to determine compliance with the standard in accordance with the procedural rules of the SDO. If more than one interpretation of the literal text has been identified, a revision shall be proposed as soon as possible to each of the SDOs to more accurately reflect the intent.

### UL Effective Date

As of \_\_\_\_\_ 200X all products Listed or Recognized by UL must comply with the requirements in this Standard.

This page intentionally left blank.

## Preface

This ISA standard is based on IEC Publication 60079-11. It is the intention of the ISA12 Committee to develop an ANSI Standard that is harmonized with IEC 60079-11 to the fullest extent possible.

This preface, as well as all footnotes and annexes, is included for information purposes and is not part of ISA-60079-11 (12.02.01)-2009.

The standards referenced within this document may contain provisions which, through reference in this text, constitute requirements of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated within this document. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards.

This document has been prepared as part of the service of ISA toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: [standards@isa.org](mailto:standards@isa.org).

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards, recommended practices, and technical reports to the greatest extent possible. *Standard for Use of the International System of Units (SI): The Modern Metric System*, published by the American Society for Testing & Materials as IEEE/ASTM SI 10-97, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all concerned individuals and interests in the development of ISA standards, recommended practices, and technical reports. Participation in the ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual, of ISA, or of any of the standards, recommended practices, and technical reports that ISA develops.

**CAUTION — ISA DOES NOT TAKE ANY POSITION WITH RESPECT TO THE EXISTENCE OR VALIDITY OF ANY PATENT RIGHTS ASSERTED IN CONNECTION WITH THIS DOCUMENT, AND ISA DISCLAIMS LIABILITY FOR THE INFRINGEMENT OF ANY PATENT RESULTING FROM THE USE OF THIS DOCUMENT. USERS ARE ADVISED THAT DETERMINATION OF THE VALIDITY OF ANY PATENT RIGHTS, AND THE RISK OF INFRINGEMENT OF SUCH RIGHTS, IS ENTIRELY THEIR OWN RESPONSIBILITY.**

**PURSUANT TO ISA'S PATENT POLICY, ONE OR MORE PATENT HOLDERS OR PATENT APPLICANTS MAY HAVE DISCLOSED PATENTS THAT COULD BE INFRINGED BY USE OF THIS DOCUMENT AND EXECUTED A LETTER OF ASSURANCE COMMITTING TO THE GRANTING OF A LICENSE ON A WORLDWIDE, NON-DISCRIMINATORY BASIS, WITH A FAIR AND REASONABLE ROYALTY RATE AND FAIR AND REASONABLE TERMS AND**

**CONDITIONS. FOR MORE INFORMATION ON SUCH DISCLOSURES AND LETTERS OF ASSURANCE, CONTACT ISA OR VISIT [WWW.ISA.ORG/STANDARDSPATENTS](http://WWW.ISA.ORG/STANDARDSPATENTS).**

**OTHER PATENTS OR PATENT CLAIMS MAY EXIST FOR WHICH A DISCLOSURE OR LETTER OF ASSURANCE HAS NOT BEEN RECEIVED. ISA IS NOT RESPONSIBLE FOR IDENTIFYING PATENTS OR PATENT APPLICATIONS FOR WHICH A LICENSE MAY BE REQUIRED, FOR CONDUCTING INQUIRIES INTO THE LEGAL VALIDITY OR SCOPE OF PATENTS, OR DETERMINING WHETHER ANY LICENSING TERMS OR CONDITIONS PROVIDED IN CONNECTION WITH SUBMISSION OF A LETTER OF ASSURANCE, IF ANY, OR IN ANY LICENSING AGREEMENTS ARE REASONABLE OR NON-DISCRIMINATORY.**

**ISA REQUESTS THAT ANYONE REVIEWING THIS DOCUMENT WHO IS AWARE OF ANY PATENTS THAT MAY IMPACT IMPLEMENTATION OF THE DOCUMENT NOTIFY THE ISA STANDARDS AND PRACTICES DEPARTMENT OF THE PATENT AND ITS OWNER.**

**HOWEVER, ISA ASKS THAT ANYONE REVIEWING THIS STANDARD WHO IS AWARE OF ANY PATENTS THAT MAY IMPACT IMPLEMENTATION OF THE STANDARD NOTIFY THE ISA STANDARDS AND PRACTICES DEPARTMENT OF THE PATENT AND ITS OWNER.**

**ADDITIONALLY, THE USE OF THIS STANDARD MAY INVOLVE HAZARDOUS MATERIALS, OPERATIONS OR EQUIPMENT. THE STANDARD CANNOT ANTICIPATE ALL POSSIBLE APPLICATIONS OR ADDRESS ALL POSSIBLE SAFETY ISSUES ASSOCIATED WITH USE IN HAZARDOUS CONDITIONS. THE USER OF THIS STANDARD MUST EXERCISE SOUND PROFESSIONAL JUDGMENT CONCERNING ITS USE AND APPLICABILITY UNDER THE USER'S PARTICULAR CIRCUMSTANCES. THE USER MUST ALSO CONSIDER THE APPLICABILITY OF ANY GOVERNMENTAL REGULATORY LIMITATIONS AND ESTABLISHED SAFETY AND HEALTH PRACTICES BEFORE IMPLEMENTING THIS STANDARD.**

**THE USER OF THIS DOCUMENT SHOULD BE AWARE THAT THIS DOCUMENT MAY BE IMPACTED BY ELECTRONIC SECURITY ISSUES. THE COMMITTEE HAS NOT YET ADDRESSED THE POTENTIAL ISSUES IN THIS VERSION.**

The following people served as members of the ISA Subcommittee ISA12.2:

| <b>NAME</b>                   | <b>COMPANY</b>                 |
|-------------------------------|--------------------------------|
| N. Ludlam, Chair              | FM Approvals Ltd.              |
| M. Coppler, Managing Director | Ametek Inc.                    |
| N. Abbatiello                 | Optimation Technology          |
| R. Allen                      | Honeywell Inc.                 |
| S. Arnold                     | Ametek Drexelbrook             |
| S. Czaniecki                  | Intrinsic Safety Concepts Inc. |
| J. Dolphin                    | PSC Solutions                  |
| A. Engler                     | Det Norske Veritas DNV         |
| C. Fabbo                      | FM Approvals                   |
| G. Garcha                     | GE Energy                      |
| J. Genre                      | Industrial Scientific Corp.    |
| C. Huntley                    | MSHA A&CC                      |
| G. Kozinski                   | GE Infrastructure Sensing      |
| R. Masek                      | CSA International              |
| J. McCormick                  | Bentley Nevada LLC             |

|               |                                |
|---------------|--------------------------------|
| J. Miller     | Detector Electronics Corp.     |
| A. Mobley     | 3M Co.                         |
| O. Murphy     | Brooks Instrument LLC          |
| J. Neagle     | Intertek ETL SEMKO             |
| A. Page       | Consultant                     |
| B. Schaefer   | Underwriters Laboratories Inc. |
| T. Schnaare   | Rosemount Inc.                 |
| A. Shvartsman | Pepperl+Fuchs                  |
| J. Thomas     | Schlumberger                   |
| K. Thompson   | MSA Co.                        |
| D. Wechsler   | Dow Chemical Co.               |

The following people served as members of ISA Committee ISA12:

| NAME                          | COMPANY                                |
|-------------------------------|----------------------------------------|
| T. Schnaare, Chair            | Rosemount Inc.                         |
| W. Lawrence, Vice Chair       | FM Approvals LLC                       |
| M. Coppler, Managing Director | Ametek Inc.                            |
| D. Ankele                     | Underwriters Laboratories Inc.         |
| L. Ballard                    | Consultant                             |
| K. Boegli                     | Phoenix Contact Inc.                   |
| D. Burns                      | Shell Exploration & Production Company |
| C. Casso                      | Nabors Industries                      |
| S. Czaniecki                  | Intrinsic Safety Concepts Inc.         |
| J. Dolphin                    | PSC Solutions                          |
| M. Dona                       | Santos Ltd.                            |
| T. Dubaniewicz                | NIOSH                                  |
| A. Engler                     | Det Norske Veritas DNV                 |
| W. Fiske                      | Intertek                               |
| G. Garcha                     | GE Energy                              |
| C. Huntley                    | MSHA A&CC                              |
| D. Jagger                     | Bifold-Fluid Power                     |
| F. Kent                       | Honeywell Inc.                         |
| P. Kovscek                    | Industrial Scientific Corp.            |
| J. Kuczka                     | Killark                                |
| N. Ludlam                     | FM Approvals Ltd.                      |
| R. Masek                      | CSA International                      |
| E. Massey                     | Baldor Electric Company                |
| J. Miller                     | Detector Electronics Corporation       |
| A. Mobley                     | 3M Company                             |
| A. Page                       | Consultant                             |
| R. Seitz                      | Artech Engineering                     |
| M. Spencer                    | Columbia Gas Transmission              |
| D. Wechsler                   | Dow Chemical Company                   |
| R. Wigg                       | E-x Solutions International Pty. Ltd.  |

This standard was approved for publication by the ISA Standards and Practices Board on

| NAME       | COMPANY                  |
|------------|--------------------------|
| J. Tatera  | Tatera & Associates Inc. |
| P. Brett   | Honeywell Inc.           |
| M. Coppler | Ametek Inc.              |

E. Cosman  
B. Dumortier  
D. Dunn  
R. Dunn  
J. Gilsinn  
E. Içayan  
J. Jamison  
D. Kaufman  
K. P. Lindner  
V. Maggioli  
T. McAviney  
G. McFarland  
R. Reimer  
N. Sands  
H. Sasajima  
T. Schnaare  
I. Verhappen  
R. Webb  
W. Weidman  
J. Weiss  
M. Widmeyer  
M. Zielinski

The Dow Chemical Company  
Schneider Electric  
Aramco Services Co.  
DuPont Engineering  
NIST/MEL  
ACES Inc.  
Husky Energy Inc.  
Honeywell  
Endress + Hauser Process Solutions AG  
Feltronics Corp.  
Jacobs Engineering Group  
Emerson Process Mgmt. Power & Water Sol.  
Rockwell Automation  
DuPont  
Yamatake Corp.  
Rosemount Inc.  
MTL Instrument Group  
ICS Secure LLC  
Worley Parsons  
Applied Control Solutions LLC  
Consultant  
Emerson Process Management

## National Differences

### GENERAL

National Differences from the text of International Electrotechnical Commission (IEC) Publication 60079-11, Explosive Atmospheres – Part 11: Equipment Protection by Intrinsic Safety “i” copyright 1999, are indicated by notations (differences) and are presented in bold text.

In the ISA publication of this standard, National Differences are presented using legislative text (strike-out and underline). The national difference type is identified in an informative annex.

There are five types of National Differences as noted below. The difference type is noted on the first line of the National Difference in the standard. The standard may not include all types of these National Differences.

The UL printed standard includes the national difference types within the body of the text. The ISA printed standard includes the national difference types in an annex at the back of the standard.

**D1** – These are National Differences which are based on **basic safety principles and requirements**, elimination of which would compromise safety for consumers and users of products.

**D2** – These are national differences from IEC requirements based on existing **safety practices**. These requirements reflect national safety practices, where empirical substantiation (for the IEC or national requirement) is not available or the text has not been included in the IEC standard.

**DC** – These are National Differences based on the **component standards** and will not be deleted until a particular component standard is harmonized with the IEC component standard.

**DE** – These are National Differences based on **editorial comments or corrections**.

**DR** – These are National Differences based on the **national regulatory requirements**.

Each national difference contains a description of what the national difference entails. Typically one of the following words is used to explain how the text of the national difference is to be applied to the base IEC text:

**Addition / Add** - An addition entails adding a complete new numbered clause, subclause, table or figure.

Addition is not meant to include adding select words to the base IEC text.

**Deletion / Delete** - A deletion entails complete deletion of an entire numbered clause, subclause, table or figure without any replacement text.

**Modification / Modify** - A modification is an altering of the existing base IEC text such as the addition, replacement or deletion of certain words or the replacement of an entire clause, subclause, table, or figure of the base IEC text.

This page intentionally left blank.

## CONTENTS

|     |                                                                                                                               |    |
|-----|-------------------------------------------------------------------------------------------------------------------------------|----|
| 1   | Scope .....                                                                                                                   | 21 |
| 2   | Normative references .....                                                                                                    | 22 |
| 3   | Terms and definitions .....                                                                                                   | 24 |
| 3.1 | General.....                                                                                                                  | 24 |
| 4   | Grouping and classification of intrinsically safe apparatus and associated apparatus ....                                     | 29 |
| 5   | Levels of protection and ignition compliance requirements of electrical apparatus .....                                       | 30 |
| 5.1 | General.....                                                                                                                  | 30 |
| 5.2 | Level of protection "ia" .....                                                                                                | 30 |
| 5.3 | Level of protection "ib" .....                                                                                                | 31 |
| 5.4 | Level of protection "ic" .....                                                                                                | 31 |
| 5.5 | Spark ignition compliance .....                                                                                               | 32 |
| 5.6 | Thermal ignition compliance .....                                                                                             | 32 |
| 5.7 | Simple apparatus .....                                                                                                        | 36 |
| 6   | Apparatus construction .....                                                                                                  | 36 |
| 6.1 | Enclosures .....                                                                                                              | 37 |
| 6.2 | Facilities for connection of external circuits .....                                                                          | 37 |
| 6.3 | Separation distances.....                                                                                                     | 41 |
| 6.4 | Protection against polarity reversal.....                                                                                     | 53 |
| 6.5 | Earth ( <u>Ground</u> ) conductors, connections and terminals .....                                                           | 53 |
| 6.6 | Encapsulation .....                                                                                                           | 54 |
| 7   | Components on which intrinsic safety depends .....                                                                            | 55 |
| 7.1 | Rating of components .....                                                                                                    | 55 |
| 7.2 | Connectors for internal connections, plug-in cards and components.....                                                        | 56 |
| 7.3 | Fuses .....                                                                                                                   | 56 |
| 7.4 | Primary and secondary cells and batteries.....                                                                                | 57 |
| 7.5 | Semiconductors .....                                                                                                          | 61 |
| 7.6 | Failure of components, connections and separations .....                                                                      | 62 |
| 7.7 | Piezo-electric devices .....                                                                                                  | 63 |
| 7.8 | Electrochemical cells for the detection of gases.....                                                                         | 63 |
| 8   | Infallible components, infallible assemblies of components and infallible connections on which intrinsic safety depends ..... | 63 |
| 8.1 | Mains transformers .....                                                                                                      | 63 |
| 8.2 | Transformers other than mains transformers .....                                                                              | 65 |
| 8.3 | Infallible windings.....                                                                                                      | 66 |
| 8.4 | Current-limiting resistors .....                                                                                              | 66 |
| 8.5 | <del>Blocking</del> Capacitors .....                                                                                          | 67 |
| 8.6 | Shunt safety assemblies.....                                                                                                  | 68 |
| 8.7 | Wiring, printed circuit board tracks, and connections .....                                                                   | 69 |
| 8.8 | Galvanically separating components.....                                                                                       | 71 |
| 9   | Diode safety barriers .....                                                                                                   | 72 |
| 9.1 | General.....                                                                                                                  | 72 |

|                                                                                                                                                             |               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| 9.2 Construction .....                                                                                                                                      | 72            |
| 10 Type verifications and type tests .....                                                                                                                  | 72            |
| 10.1 Spark ignition test .....                                                                                                                              | 72            |
| 10.2 Temperature tests .....                                                                                                                                | 77            |
| 10.3 Dielectric strength tests .....                                                                                                                        | 78            |
| 10.4 Determination of parameters of loosely specified components .....                                                                                      | 78            |
| 10.5 Tests for cells and batteries .....                                                                                                                    | 78            |
| 10.6 Mechanical tests .....                                                                                                                                 | 80            |
| 10.7 Tests for apparatus containing piezoelectric devices .....                                                                                             | 81            |
| 10.8 Type tests for diode safety barriers and safety shunts .....                                                                                           | 81            |
| 10.9 Cable pull test .....                                                                                                                                  | 82            |
| 10.10 Transformer tests .....                                                                                                                               | 82            |
| 11 Routine verifications and tests .....                                                                                                                    | 83            |
| 11.1 Routine tests for diode safety barriers .....                                                                                                          | 83            |
| 11.2 Routine tests for infallible transformers .....                                                                                                        | 83            |
| 12 Marking .....                                                                                                                                            | 84            |
| 12.1 General .....                                                                                                                                          | 84            |
| 12.2 Marking of connection facilities .....                                                                                                                 | 85            |
| 12.3 Warning markings .....                                                                                                                                 | 85            |
| 12.4 Examples of marking .....                                                                                                                              | 85            |
| 13 Documentation .....                                                                                                                                      | 87            |
| Annex A (normative) Assessment of intrinsically safe circuits .....                                                                                         | 89            |
| Annex B (normative) Spark test apparatus for intrinsically safe circuits .....                                                                              | 112           |
| Annex C (informative) Measurement of creepage distances, clearances and separation<br>distances through casting compound and through solid insulation ..... | 124           |
| Annex D (informative) Encapsulation .....                                                                                                                   | 128           |
| Annex E (informative) Transient energy test .....                                                                                                           | 132           |
| Annex F (normative) Alternative separation distances for assembled printed circuit<br>boards and separation of components .....                             | 136           |
| Annex G (informative) United States major deviations .....                                                                                                  | 139           |
| Annex H (informative) National Differences Types noted in ISA-60079-11 .....                                                                                | 141           |
| Figure 1 – Separation of intrinsically safe and non-intrinsically safe terminals .....                                                                      | 40            |
| Figure 2 – Example of separation of conducting parts .....                                                                                                  | 45            |
| Figure 3 – Determination of creepage distances .....                                                                                                        | 49            |
| Figure 4 – Creepage distances and clearances on printed circuit boards .....                                                                                | 50            |
| Figure 5 – Examples of independent and non-independent connecting elements .....                                                                            | 54            |
| Figure 6 – Infallible solder connection of surface mount component in accordance with<br>8.7 c) 3) .....                                                    | 70            |
| Figure A.1 – Resistive circuits .....                                                                                                                       | 92            |
| <del>Figure A.2 – Group I capacitive circuits .....</del>                                                                                                   | <del>93</del> |
| Figure A.3 – Group II capacitive circuits .....                                                                                                             | 94            |

|                                                                                                                                   |               |
|-----------------------------------------------------------------------------------------------------------------------------------|---------------|
| Figure A.4 – Inductive circuits of Group II .....                                                                                 | 95            |
| <del>Figure A.5 – Group I inductive circuits .....</del>                                                                          | <del>96</del> |
| Figure A.6 – Group IIC inductive circuits .....                                                                                   | 97            |
| Figure A.7 – Simple inductive circuit .....                                                                                       | 98            |
| Figure A.8 – Simple capacitive circuit .....                                                                                      | 98            |
| Figure A.9 – Equivalent capacitance .....                                                                                         | 110           |
| Figure B.1 – Spark test apparatus for intrinsically safe circuits .....                                                           | 116           |
| Figure B.2 – Cadmium contact disc .....                                                                                           | 117           |
| Figure B.3 – Wire holder .....                                                                                                    | 117           |
| Figure B.4 – Example of a practical design of spark test apparatus .....                                                          | 118           |
| Figure B.5 – Example of an explosion pressure switch .....                                                                        | 119           |
| Figure B.6 – Example of automatic stopping by means of an explosion pressure switch ....                                          | 120           |
| Figure B.7 – Arrangement for fusing tungsten wires .....                                                                          | 121           |
| Figure B.8 – Circuit diagram for fusing tungsten wires .....                                                                      | 122           |
| Figure C.1 – Measurement of clearance .....                                                                                       | 124           |
| Figure C.2 – Measurement of composite distances .....                                                                             | 125           |
| Figure C.3 – Measurement of creepage .....                                                                                        | 126           |
| Figure C.4 – Measurement of composite creepage .....                                                                              | 127           |
| Figure D.1 – Examples of encapsulated assemblies conforming to 6.3.4 and 6.6 .....                                                | 129           |
| Figure D.2a – Mechanical .....                                                                                                    | 130           |
| Figure D.2b – Temperature .....                                                                                                   | 130           |
| Figure D.2c – Separation of circuits .....                                                                                        | 130           |
| Figure D.2d – Protection of fuses in an intrinsically safe circuit .....                                                          | 131           |
| Figure D.2e – Exclusion of gas .....                                                                                              | 131           |
| Figure D.2 – Applications of encapsulation without enclosure .....                                                                | 131           |
| Figure E.1 – Example of test circuit .....                                                                                        | 133           |
| Figure E.2 – Example of output waveform .....                                                                                     | 134           |
| <br>Table 1 – Exclusion of specific clauses of ANSI/ISA-60079-0 <del>IEC 60079-0</del> .....                                      | <br>21        |
| Table 2 – Assessment of temperature classification according to component size and ambient temperature .....                      | 33            |
| Table 2a) – Requirements for T4 <del>and Group I</del> .....                                                                      | 33            |
| Table 2b) – Variation in maximum power dissipation with ambient temperature for components not less than 20 mm <sup>2</sup> ..... | 33            |
| Table 3 – Temperature classification of copper wiring (in a maximum ambient temperature of 40 °C) .....                           | 34            |
| Table 4 – Temperature classification of tracks on printed circuit boards (in a maximum ambient temperature of 40 °C) .....        | 35            |
| Table 5 – Clearances, creepage distances and separations .....                                                                    | 44            |
| Table 6 – Minimum foil thickness or minimum wire diameter of the screen in relation to the rated current of the fuse .....        | 64            |

|                                                                                                                                                                                                  |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table 7 – Compositions of explosive test mixtures adequate for 1,0 safety factor .....                                                                                                           | 74  |
| Table 8 – Compositions of explosive test mixtures adequate for 1,5 safety factor .....                                                                                                           | 74  |
| Table 9 – Routine test voltages for infallible transformers .....                                                                                                                                | 84  |
| Table 10 – Text of warning markings .....                                                                                                                                                        | 85  |
| Table A.1 – Permitted short-circuit current corresponding to the voltage and the apparatus group .....                                                                                           | 99  |
| Table A.2 – Permitted capacitance corresponding to the voltage and the apparatus group .....                                                                                                     | 104 |
| Table A.3 – Permitted reduction of effective capacitance when protected by a series resistance .....                                                                                             | 110 |
| Table F.1 – Clearances, creepage distances and separations for level of protection "ia" and "ib" when ingress protected, and special conditions of material and installation are fulfilled ..... | 135 |
| Table F.2 – Clearances, creepage distances and separations for level of protection "ic" when ingress is protected by an enclosure or by special conditions of installation .....                 | 136 |

## Foreword

The entire text of IEC 60079-11:2006 is included in this document. U.S. National Deviations are shown by ~~strikeout~~ through deleted text and underlining of added text. Tables, or portions of tables, that are to be deleted are shown as shaded; figures to be deleted are marked with the overlay "X." Some tables have been reformatted to allow for US standard paper sizes. There are seven annexes in this standard. Annexes A, B and F are normative and form part of the requirements of this standard. Annexes C, D, E, G and H are informative and are not considered part of this standard.

The significant changes with respect to the previous edition are listed below:

- introduction of level of protection “ic” (this level of protection has been introduced to allow removal of the 'energy limitation' concept from ANSI/ISA-60079-15);
- introduction of Annex F that allows reduction in segregation distance requirements when the pollution degree has been reduced by installation or enclosure;
- introduction of alternative spark test apparatus construction when used with high current circuits;
- introduction of Annex E that provides a method for transient energy test
- changes in the table of 'Temperature classification of tracks on PCB's' to allow correlation with IPC-2152;
- allowing alternative methods of rating resistors when used to limit the discharge from capacitance;
- introduction of methods to deal with the spark ignition energy consideration when high current low voltage cells and batteries are used;
- introduction of tests to measure the maximum pressure in sealed battery containers;
- introduction of methods to deal with fault application on voltage enhancement IC's;
- introduction of infallible connection methods for SMD's (surface mount devices);
- introduction of alternative methods to deal with the spark ignition energy in circuits with both inductance and capacitance;
- introduction of alternative high voltage test for transformers;
- introduction of methods to assess the reduction of effective capacitance when protected by series resistances;

This page intentionally left blank.

## 1 Scope

This ~~standard part of IEC 60079~~ specifies the construction and testing of intrinsically safe apparatus intended for use in Class I, Zone 0, 1, or 2 hazardous (classified) locations as defined by the National Electrical Code, ANSI/NFPA 70 ~~an explosive gas atmosphere~~ 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 apparatus in which the electrical circuits themselves are incapable of causing an explosion in the surrounding explosive atmospheres.

This standard is also applicable to electrical apparatus or parts of electrical apparatus located outside the explosive gas atmosphere or protected by another type of protection listed in ANSI/ISA-60079-0 ~~IEC 60079-0~~, where the intrinsic safety of the electrical circuits in the explosive gas atmosphere may depend upon the design and construction of such electrical apparatus or parts of such electrical apparatus. The electrical circuits exposed to the explosive gas atmosphere are evaluated for use in such an atmosphere by applying this standard.

~~The requirements for intrinsically safe systems are provided in IEC 60079-25.~~ The requirements for intrinsically safe concepts for fieldbus are provided in ISA-60079-27 ~~IEC 60079-27~~.

This standard supplements and modifies the general requirements of ANSI/ISA-60079-0 ~~IEC 60079-0~~, except as indicated in Table 1. Where a requirement of this standard conflicts with a requirement of ANSI/ISA-60079-0 ~~IEC 60079-0~~, the requirements of this standard shall take precedence.

If associated apparatus is placed in the explosive gas atmosphere, it must be protected by an appropriate type of protection listed in ANSI/ISA-60079-0 ~~IEC 60079-0~~, and then the requirements of that method of protection together with the relevant parts of ANSI/ISA-60079-0 ~~IEC 60079-0~~ also apply to the associated apparatus.

**Table 1 – Exclusion of specific clauses of ANSI/ISA-60079-0 ~~IEC 60079-0~~**

| Clause or subclause of <u>ANSI/ISA-60079-0</u> <del>IEC 60079-0</del> |                                                                        | Intrinsically safe apparatus | Associated apparatus |
|-----------------------------------------------------------------------|------------------------------------------------------------------------|------------------------------|----------------------|
| 4.2.2                                                                 | Group II – Surface temperature marking                                 | Applies                      | Excluded             |
| 5.3                                                                   | Maximum surface temperature                                            | Applies                      | Excluded             |
| 5.4                                                                   | Surface temperature and ignition temperature                           | Applies                      | Excluded             |
| 5.5                                                                   | Small components                                                       | Applies                      | Excluded             |
| 6.3                                                                   | Opening times                                                          | Excluded                     | Excluded             |
| 7.1.1                                                                 | Applicability                                                          | Applies                      | Excluded             |
| 7.1.2                                                                 | Specification of materials                                             | Applies                      | Excluded             |
| 7.1.3*                                                                | Plastic materials                                                      | Excluded                     | Excluded             |
| 7.2*                                                                  | Thermal endurance                                                      | Excluded                     | Excluded             |
| 7.3                                                                   | Electrostatic charges on external non-metallic materials of enclosures | Applies                      | Excluded             |
| 7.3.2                                                                 | Avoidance of a build-up electrostatic charge                           | Applies                      | Excluded             |
| 7.4                                                                   | Threaded holes                                                         | Excluded                     | Excluded             |
| 8.1                                                                   | Material composition                                                   | Applies                      | Excluded             |

| Clause or subclause of <del>ANSI/ISA-60079-0 IEC 60079-0</del> |                                                                          | Intrinsically safe apparatus | Associated apparatus |
|----------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------|----------------------|
| 8.2                                                            | Threaded holes                                                           | Excluded                     | Excluded             |
| 9                                                              | Fasteners                                                                | Excluded                     | Excluded             |
| 10                                                             | Interlocking devices                                                     | Excluded                     | Excluded             |
| 11                                                             | Bushings                                                                 | Excluded                     | Excluded             |
| 12                                                             | Materials used for cementing                                             | Excluded                     | Excluded             |
| 14                                                             | Connection facilities and terminal compartments                          | Excluded                     | Excluded             |
| 15                                                             | Connection facilities for earthing or bonding conductors                 | Excluded                     | Excluded             |
| 16.5                                                           | Conductor temperature                                                    | Excluded                     | Excluded             |
| 17                                                             | Supplementary requirements for rotating electrical machines              | Excluded                     | Excluded             |
| 18                                                             | Supplementary requirements for switchgear                                | Excluded                     | Excluded             |
| 19                                                             | Supplementary requirements for fuses                                     | Excluded                     | Excluded             |
| 20                                                             | Supplementary requirements for plugs and sockets                         | Excluded                     | Excluded             |
| 21                                                             | Supplementary requirements for luminaires                                | Excluded                     | Excluded             |
| 22                                                             | Supplementary requirements for caplights and handlights                  | Excluded                     | Excluded             |
| 23.1                                                           | Batteries                                                                | Applies                      | Excluded             |
| 26.4                                                           | Tests of enclosures                                                      | Applies                      | Excluded             |
| 26.5.1                                                         | Temperature measurement                                                  | Applies                      | Excluded             |
| 26.5.2                                                         | Thermal shock test                                                       | Excluded                     | Excluded             |
| 26.5.3                                                         | Small component ignition test                                            | Applies                      | Excluded             |
| 26.6                                                           | Torque test for bushings                                                 | Excluded                     | Excluded             |
| 26.7*                                                          | Non-metallic enclosures or non-metallic parts of enclosures              | Excluded                     | Excluded             |
| 26.8*                                                          | Thermal endurance to heat                                                | Excluded                     | Excluded             |
| 26.9*                                                          | Thermal endurance to cold                                                | Excluded                     | Excluded             |
| 26.10*                                                         | Resistance to light                                                      | Excluded                     | Excluded             |
| 26.11*                                                         | Resistance to chemical agents for Group I electrical apparatus           | Excluded                     | Excluded             |
| 26.12                                                          | Earth continuity                                                         | Excluded                     | Excluded             |
| 26.13                                                          | Surface resistance test of parts of enclosures or non-metallic materials | Applies                      | Excluded             |
| 26.14                                                          | Charging tests                                                           | Applies                      | Excluded             |
| 26.15                                                          | Measurement of capacitance                                               | Applies                      | Excluded             |
| Annex A                                                        | Ex cable glands                                                          | Excluded                     | Excluded             |
| * indicates that these requirements apply for 6.1.2a) only.    |                                                                          |                              |                      |

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ~~ANSI/ISA-60079-0 IEC 60079-0~~. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60079-0:2004, *Electrical apparatus for explosive gas atmospheres — Part 0: General requirements*~~

ANSI/ISA-60079-0 (12.00.01)-2005, Electrical Apparatus for Use in Class I, Zones 0, 1 & 2 Hazardous (Classified) Locations: General Requirements

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

ANSI/ISA-60079-7 (12.16.01) Electrical Apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations: Type of Protection - Increased Safety "e"

~~IEC 60079-25, Electrical apparatus for explosive gas atmospheres – Part 25: Intrinsically safe systems~~

~~IEC 60079-27, Electrical apparatus for explosive gas atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO) and Fieldbus non-incendive concept (FNICO)~~

ISA-60079-27 (12.02.04) Fieldbus Intrinsically Safe Concept (FISCO) and Fieldbus Non-Incendive Concept (FNICO)

IEC 60085, Electrical insulation – Thermal classification

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

UL746A, Polymeric Materials B Short Term Property Evaluations, Fifth edition, (Edition Date November 1, 2000)

IEC 60127 (all parts), Miniature fuses

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

IEC 60317-7, Specifications for particular types of winding wires – Part 7: Polyimide enamelled round copper wire, class 220

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

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

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

IEC 60664-1:2002, Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests <sup>1)</sup>

Amendment 1 (2000)

Amendment 2 (2002)

IEC 60664-3:2003, Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution

---

<sup>1)</sup> A consolidated edition 1.2 exists, that comprises IEC 60664-1 and its amendments 1 and 2.

ANSI/UL 840, Insulation Coordination Including Clearances and Creepage Distances for Electrical Equipment

ANSI/UL 248-1, Low-Voltage Fuses – Part 1: General Requirements

### 3 Terms and definitions

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

#### 3.1 General

##### 3.1.1

##### **intrinsic safety “i”**

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

##### 3.1.2

##### **associated apparatus**

electrical apparatus which contains both energy-limited and non-energy-limited circuits and is constructed so that the non energy-limited circuits cannot adversely affect the energy-limited circuits

NOTE 1 Associated apparatus may be either:

- a) electrical apparatus which has an alternative type of protection included in this standard for use in the appropriate explosive gas atmosphere,
- b) electrical apparatus not so protected and which therefore is not to be used within an explosive gas atmosphere, for example, a recorder which is not of itself in an explosive gas atmosphere but is connected to a thermocouple situated within an explosive gas atmosphere where only the recorder input circuit is energy limited.

[Definition 3.2 of ANSI/ISA-60079-0 ~~IEC 60079-0~~]

NOTE 2 For the purposes of this standard associated apparatus is also electrical apparatus which contains both intrinsically safe circuits and non-intrinsically safe circuits and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits and includes

- a) electrical apparatus which has another type of protection listed in ANSI/ISA-60079-0 ~~IEC 60079-0~~ for use in the appropriate explosive gas atmosphere, or
- b) electrical apparatus not so protected and which, therefore, shall not be used within an explosive gas atmosphere, for example a recorder which is not itself in an explosive gas atmosphere, but is connected to a thermocouple situated within an explosive atmosphere where only the recorder input circuit is intrinsically safe, or
- c) chargers or interfaces ~~not used in an unclassified location the hazardous area~~, but which are connected to hazardous (classified) location area equipment in the safe area for charging, data downloading, etc.

[IEV 426-11-03, modified]

##### 3.1.3

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

electrical apparatus in which all the circuits are intrinsically safe circuits

##### 3.1.4

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

circuit in which any spark or any thermal effect produced in the conditions specified in this standard, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive gas atmosphere

**3.1.5****simple apparatus**

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

**3.2****coating**

insulating material such as varnish or dry film laid on the surface of the assembly

NOTE Coating and base material of a printed board form an insulating system that may have properties similar to solid insulation.

[Definition 3.5 of IEC 60664-3]

**3.3****conformal coating**

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

[Definition 2.1 of IEC 61086-1]

**3.4****control drawing**

drawing or other document that is prepared by the manufacturer for the intrinsically safe or associated apparatus, detailing the electrical parameters to allow for interconnections to other circuits or apparatus

**3.5****diode safety barrier**

assemblies incorporating shunt diodes or diode chains (including Zener diodes) protected by fuses or resistors or a combination of these, manufactured as an individual apparatus rather than as part of a larger apparatus

**3.6****entity concept**

method used to determine acceptable combinations of intrinsically safe apparatus and associated apparatus through the use of intrinsically safe parameters assigned to connection facilities

**3.7****faults****3.7.1****countable fault**

fault which occurs in parts of electrical apparatus conforming to the constructional requirements of ISA-60079-11 ~~IEC 60079-11~~ (this standard)

**3.7.2****fault**

any defect of any component, separation, insulation or connection between components, not defined as infallible by ISA-60079-11 ~~IEC 60079-11~~, upon which the intrinsic safety of a circuit depends

**3.7.3****non-countable fault**

fault which occurs in parts of electrical apparatus not conforming to the constructional requirements of ISA-60079-11 ~~IEC 60079-11~~

**3.8****normal operation**

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

NOTE 1 The limits specified by the manufacturer may include persistent operational conditions, e.g. operation of a motor on a duty cycle

NOTE 2 Variation of the supply voltage within stated limits and any other operational tolerance is part of normal operation

[Definition 3.19 of ANSI/ISA-60079-0 ~~IEC 60079-0~~]

NOTE 3 This includes opening, shorting and earthing of the external interconnecting cable.

**3.9****free space**

intentionally created space surrounding components or space inside components

**3.10****fuse rating**

$I_n$

current rating of a fuse as specified in IEC 60127, ANSI/UL 248-1 or in the manufacturer's specification

**3.11****infallibility****3.11.1****infallible component or infallible assembly of components**

component or assembly of components that is considered as not subject to certain fault modes as specified in ISA-60079-11 ~~IEC 60079-11~~

The probability of such fault modes occurring in service or storage is considered to be so low that they are not to be taken into account.

**3.11.2****infallible connection**

connections, including joints and interconnecting wiring and printed circuit board tracks, that are not considered according to ISA-60079-11 ~~IEC 60079-11~~ as becoming open-circuited in service or storage

The probability of such fault modes occurring in service or storage is considered to be so low that they are not to be taken into account.

**3.11.3****infallible separation or insulation**

separation or insulation between electrically conductive parts that is considered as not subject to short circuits as specified in ISA-60079-11 ~~IEC 60079-11~~

The probability of such fault modes occurring in service or storage is considered to be so low that they are not to be taken into account.

**3.12****internal wiring**

wiring and electrical connections that are made within the apparatus by its manufacturer

NOTE Within a rack or panel, interconnections between separate pieces of apparatus made in accordance with detailed instructions from the manufacturer are considered to be internal wiring.

**3.13****live maintenance**

maintenance activities carried out while the associated apparatus, intrinsically safe apparatus and circuits are energized

**3.14****maximum external inductance to resistance ratio**

$L_o/R_o$

maximum value of ratio of inductance to resistance which may be connected to the external connection facilities of the electrical apparatus without invalidating intrinsic safety

**3.15****maximum internal inductance to resistance ratio**

$L_i/R_i$

maximum value of ratio of inductance to resistance which is considered as appearing at the external connection facilities of the electrical apparatus

**3.16****maximum r.m.s. a.c. or d.c. voltage**

$U_m$

maximum voltage that can be applied to the non energy-limited connection facilities of associated apparatus without invalidating the type of protection

[Definition 3.12.11 of ANSI/ISA-60079-0 ~~IEC 60079-0~~]

NOTE 1 This additionally applies to the maximum voltage that can be applied to non-intrinsically safe connection facilities of intrinsically safe apparatus (for example, charging connections on battery operated apparatus, where charging is only done in the unclassified location ~~non-hazardous area~~).

NOTE 2 The value of  $U_m$  may be different at different sets of connection facilities, and may be different for a.c. and d.c. voltages.

**3.17****overvoltage category**

numeral defining a transient overvoltage condition

[Definition 1.3.10 of IEC 60664-1]

NOTE Overvoltage categories I, II, III and IV are used, see 2.2.2.1 of IEC 60664-1.

**3.18****pollution degree**

numeral characterizing the expected pollution of the micro-environment

[Definition 1.3.13 of IEC 60664-1]

NOTE Pollution degrees 1, 2, 3 and 4 are used.

**3.19****protective extra-low voltage (PELV)**

extra-low voltage system which is not electrically separated from earth but which otherwise satisfies the requirements for SELV

NOTE A 50 V centre-tapped earth system is a PELV system.

**3.20****rated insulation voltage**

r.m.s. withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified (long-term) withstand capability of its insulation

[Definition 1.3.9.1 of IEC 60664-1]

NOTE The rated insulation voltage is not necessarily equal to the rated voltage of equipment which is primarily related to functional performance.

**3.21****recurring peak voltage**

maximum peak value of periodic excursions of the voltage waveform resulting from distortions of an a.c. voltage or from a.c. components superimposed on a d.c. voltage

NOTE Random overvoltages, for example due to occasional switching, are not considered as recurring peak voltages.

**3.22****safety extra-low voltage (SELV)**

extra-low voltage system (i.e. normally not exceeding 50 V a.c. or 120 V ripple-free d.c.) electrically separated from earth and from other systems in such a way that a single fault cannot give rise to an electric shock

NOTE A 50 V earth free system is a SELV system.

**3.23****spacings****3.23.1****clearance**

shortest distance in air between two conductive parts

NOTE This distance applies only to parts that are exposed to the atmosphere and not to parts which are insulated parts or covered with casting compound.

**3.23.2****distance through casting compound**

shortest distance through a casting compound between two conductive parts

**3.23.3****distance through solid insulation**

shortest distance through solid insulation between two conductive parts

**3.23.4****creepage distance**

shortest distance along the surface of an insulating medium in contact with air between two conductive parts

NOTE The distance concerned here is, for example, applicable to printed circuits that have no coating in accordance with 6.4.8, where the insulation across which the creepage distance is measured is in direct contact with the air.

**3.23.5****distance under coating**

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

**3.24****void**

unintentional space created as a consequence of the encapsulation process

**3.25****intrinsically safe system**

assembly of interconnected items of apparatus that may comprise intrinsically safe apparatus and associated apparatus, and interconnecting cables in which the circuits within those parts of the system that may be exposed to explosive gas atmospheres are intrinsically safe circuits.

**3.26****apparatus and systems of level of protection “ia”**

electrical apparatus and systems containing intrinsically safe circuits that are incapable of causing ignition, with the appropriate safety factor when up to two countable faults are applied and, in addition, those non-countable faults that give the most onerous condition.

**3.27****apparatus and systems of level of protection “ib”**

electrical apparatus and systems containing intrinsically safe circuits that are incapable of causing ignition with the appropriate safety factor when up to one countable fault is applied and, in addition, those noncountable faults that give the most onerous condition.

**3.28****apparatus and systems of level of protection “ic”**

electrical apparatus and systems containing intrinsically safe circuits that are incapable of causing ignition with the appropriate safety factor in normal operation.

## **4 Grouping and classification of intrinsically safe apparatus and associated apparatus**

Intrinsically safe apparatus and associated apparatus shall be grouped and classified in accordance with Clauses 4 and 5 of ANSI/ISA-60079-0 ~~IEC 60079-0~~.

## 5 Levels of protection and ignition compliance requirements of electrical apparatus

### 5.1 General

Intrinsically safe apparatus and intrinsically safe parts of associated apparatus shall be placed in levels of protection "ia", "ib" or "ic".

NOTE: The National Electrical Code® (NEC®), through the 2008 edition only recognizes levels of protection "ia" for Class I, Zone 0 and "ib" for Class I, Zone 1 hazardous (classified) locations. No recognition is made for level of protection "ic".

The requirements of this standard shall apply to all levels of protection unless otherwise stated. In the determination of level of protection "ia", "ib" or "ic", failure of components and connections shall be considered in accordance with 7.6. Failure of separations between conductive parts shall be considered in accordance with 6.3. The determination shall include opening, shorting and earthing of the external interconnecting cable.

The maximum intrinsically safe entity parameters for the intrinsically safe apparatus and associated apparatus shall be determined taking into account the requirements for spark ignition compliance of 5.5 and thermal ignition compliance of 5.6.

For circuits of associated apparatus which are connected to safety extra low-voltage circuits (SELV) or protective extra low-voltage circuits (PELV) circuits,  $U_m$  shall only be applied as a 'common mode' voltage, with the nominal operating voltage applied for the differential mode signal between the circuit conductors. (Typical examples are RS-232, RS-485 or 4-20 mA circuits). Apparatus relying on SELV or PELV circuits shall be marked according to with an "X" ~~as required by item i) of 29.2 of ANSI/ISA-60079-0 IEC 60079-0.~~

Where live maintenance procedures are specified by the manufacturer in the documentation provided, the effects of this live maintenance shall not invalidate intrinsic safety and this shall be considered during the testing and assessment.

NOTE 1 Apparatus may be specified with more than one level of protection, and may have different parameters for each level of protection.

NOTE 2 Guidance on the assessment of intrinsically safe circuits for spark ignition circuits is contained in Annex A. Details of the spark test apparatus are given in Annex B

NOTE 3 For the application of  $U_m$ ,  $U_i$  in the following clauses, any voltage up to the maximum voltage may be applied for the assessment.

NOTE 4 The value of  $U_m$  may be different at different sets of connection facilities, and may be different for a.c. and d.c. voltages.

### 5.2 Level of protection "ia"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ia" shall not be capable of causing ignition in each of the following circumstances:

- a) in normal operation and with the application of those non-countable faults which give the most onerous condition;
- b) in normal operation and with the application of one countable fault plus those non-countable faults which give the most onerous condition;
- c) in normal operation and with the application of two countable faults plus those non-countable faults which give the most onerous condition.

The non-countable faults applied may differ in each of the above circumstances.

In testing or assessing the circuits for spark ignition, the following safety factors shall be applied in accordance with 10.1.4.2:

- for both a) and b) 1,5
- for c) 1,0

The safety factor applied to voltage or current for determination of surface temperature classification shall be 1,0 in all cases.

If only one countable fault can occur, the requirements of b) are considered to give a level of protection of "ia" if the test requirements for "ia" can then be satisfied. If no countable faults can occur the requirements of a) are considered to give a level of protection of "ia" if the test requirements for "ia" can then be satisfied.

In the case of systems, the countable faults specified will be applied to the system as a whole and not simultaneously to each item of electrical apparatus in the system. For example, a level of protection 'ia' system comprising two pieces of apparatus will have up to two countable faults applied, not four.

### 5.3 Level of protection "ib"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ib" shall not be capable of causing ignition in each of the following circumstances:

- a) in normal operation and with the application of those non-countable faults which give the most onerous condition;
- b) in normal operation and with the application of one countable fault plus the application of those non-countable faults which give the most onerous condition.

The non-countable faults applied may differ in each of the above circumstances.

In testing or assessing the circuits for spark ignition, a safety factor of 1,5 shall be applied in accordance with 10.1.4.2. The safety factor applied to the voltage or current for the determination of surface temperature classification shall be 1,0 in all cases.

If no countable fault can occur the requirements of a) are considered to give a level of protection of "ib" if the test requirements for "ib" can be satisfied.

In the case of systems, the countable fault specified shall be applied to the system as a whole and not simultaneously to each item of electrical apparatus in the system. For example, a level of protection 'ib' system comprising two pieces of apparatus will have only one countable fault applied, not two.

### 5.4 Level of protection "ic"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ic" shall not be capable of causing ignition in normal operation. Where distances are critical for safety, they shall meet the requirements of Table 5 or Table F.2.

In testing or assessing the circuits for spark ignition, a safety factor of 1,0 shall be applied in accordance with 10.1.4.2. The safety factor applied to the voltage or current for the determination of surface temperature classification shall be 1,0 in all cases.

NOTE The concept of faults does not apply to this level of protection. Infallible components and assemblies, as in Clause 8, are not applicable. For level of protection "ic", the term 'infallible' should be read as 'meeting the requirements of 7.1'.

## 5.5 Spark ignition compliance

The circuit shall be assessed and/or tested for the successful limitation of the spark energy that may be capable of causing ignition of the explosive atmosphere, at each point where an interruption or interconnection may occur, in accordance with 10.1.

## 5.6 Thermal ignition compliance

### 5.6.1 General

All surfaces of components, enclosures and the wiring which may come in contact with explosive gas atmospheres shall be assessed and/or tested for the maximum temperature. The requirements for the maximum temperature allowable after the application of faults, as provided in 5.2, 5.3 and 5.4, are given in Clause 5 of ANSI/ISA-60079-0 ~~IEC 60079-0~~.

Tests, if required, are specified in 10.2.

NOTE 1 The requirements of this clause are not applicable to associated apparatus protected by another type of protection listed in ANSI/ISA-60079-0 ~~IEC 60079-0~~ or located outside the hazardous (classified) location area.

NOTE 2 Care should be taken in the selection of materials to be used adjacent to components that could exhibit excessive temperatures such as cells, batteries, or components that could dissipate power greater than 1,3 W, under the fault conditions defined in Clause 5, to prevent the secondary ignition of the explosive gas atmosphere by for example, heating or burning of the printed circuit boards, coatings or component packaging.

### 5.6.2 Temperature for small components

Small components, for example transistors or resistors, whose temperature exceeds that permitted for the temperature classification, shall be acceptable providing that, when tested in accordance with 26.5.3 of ANSI/ISA-60079-0 ~~IEC 60079-0~~, small components do not cause ignitions.

~~For Group I, the test mixture shall be  $(6,5 \pm 0,3)$  % methane in air.~~

Alternatively, where no catalytic or other chemical reactions can result, one of the following is acceptable:

- a) for Group II T4 ~~and Group I~~ temperature classification components shall conform to Table 2a), ~~including~~ or the relevant reduction of permitted maximum dissipation with increased ambient temperature listed in Table 2b);
- b) for Group II T5 classification the surface temperature of a component with a surface area smaller than 10 cm<sup>2</sup> shall not exceed 150 °C.

In addition the permitted higher temperature shall not invalidate the type of protection, for example, by causing the component or adjacent parts of the apparatus to exceed any safety related rating, or to deteriorate or be distorted so as to invalidate critical creepage and clearance distances.

**Table 2 – Assessment of temperature classification according to component size and ambient temperature**

**Table 2a) – Requirements for T4 and Group I**

| Total surface area excluding lead wires   | Group II T4                       | Group I<br>Dust excluded |
|-------------------------------------------|-----------------------------------|--------------------------|
|                                           | Maximum surface temperature<br>°C |                          |
| <20 mm <sup>2</sup>                       | 275                               | 950                      |
| ≥ 20 mm <sup>2</sup> ≤ 10 cm <sup>2</sup> | 200                               | 450                      |
| >10 cm <sup>2</sup>                       | 135                               | 450                      |

**Table 2b) – Variation in maximum power dissipation with ambient temperature for components not less than 20 mm<sup>2</sup>**

| Maximum ambient temperature | ° C | Apparatus group | 40  | 50   | 60   | 70   | 80  |
|-----------------------------|-----|-----------------|-----|------|------|------|-----|
| Maximum power dissipation   | W   | Group II        | 1,3 | 1,25 | 1,2  | 1,1  | 1,0 |
|                             |     | Group I         | 3,3 | 3,22 | 3,15 | 3,07 | 3,0 |

### 5.6.3 Wiring within apparatus

The maximum permissible current corresponding to the maximum wire temperature due to self-heating shall either be taken from Table 3 for copper wires, or can be calculated from the following equation for metals in general.

$$I = I_f \left[ \frac{t(1+aT)}{T(1+at)} \right]^{1/2}$$

where

$a$  is the temperature coefficient of resistance of the wire material (0,004 284 K<sup>-1</sup> for copper, 0,004 201 K<sup>-1</sup> for gold);

$I$  is the maximum permissible current r.m.s., in amperes;

$I_f$  is the current at which the wire melts at the specified ambient temperature, in amperes;

$T$  is the melting temperature of the wire material in degrees Celsius (1 083 °C for copper, 1 064 °C for gold);

$t$  is the threshold temperature, in degrees Celsius, of the applicable temperature class. The value of  $t$  is the wire temperature due to self-heating and ambient temperature.

*Example: fine copper wire (Temp Code=T4)*

$a = 0,004\,284\text{ K}^{-1}$

$I_f = 1,6\text{ A}$  (determined experimentally or specified by the wire manufacturer)

$T = 1\,083\text{ °C}$

$t$  for T4 (small component,  $t \leq 275\text{ °C}$ )

Applying the equation

$I = 1,3 \text{ A}$  (This is the maximum normal or fault current which may be allowed to flow to prevent the wire temperature from exceeding 275 °C.)

**Table 3 – Temperature classification of copper wiring  
(in a maximum ambient temperature of 40 °C)**

| Diameter<br>(see Note 4)<br><br>mm | Cross-sectional area<br>(see Note 4)<br><br>mm <sup>2</sup> | Maximum permissible current for temperature classification<br>A |      |      |
|------------------------------------|-------------------------------------------------------------|-----------------------------------------------------------------|------|------|
|                                    |                                                             | T1 to T4 and<br>Group I                                         | T5   | T6   |
| 0,035                              | 0,000 962                                                   | 0,53                                                            | 0,48 | 0,43 |
| 0,05                               | 0,001 96                                                    | 1,04                                                            | 0,93 | 0,84 |
| 0,1                                | 0,007 85                                                    | 2,1                                                             | 1,9  | 1,7  |
| 0,2                                | 0,031 4                                                     | 3,7                                                             | 3,3  | 3,0  |
| 0,35                               | 0,096 2                                                     | 6,4                                                             | 5,6  | 5,0  |
| 0,5                                | 0,196                                                       | 7,7                                                             | 6,9  | 6,7  |

NOTE 1 The value given for maximum permissible current, in amperes, is the r.m.s. a.c. or d.c. value.

NOTE 2 For stranded conductors, the cross-sectional area is taken as the total area of all strands of the conductor.

NOTE 3 The table also applies to flexible flat conductors, such as in ribbon cable, but not to printed circuit conductors for which see 5.6.4.

NOTE 4 Diameter and cross-sectional area are the nominal dimensions specified by the wire manufacturer.

NOTE 5 Where the maximum power does not exceed 1,3 W the wiring can be assigned a temperature classification of T4 and is acceptable for Group I. For Group I where dust is excluded, a maximum power of 3,3 W is permitted for ambient temperatures of up to 40 °C. Refer to Table 2b) where derating is required for ambient temperatures greater than 40 °C.

### 5.6.4 Tracks on printed circuit boards

The temperature classification of tracks of printed circuit boards shall be determined using available data or by actual measurement.

Where the tracks are made of copper, the temperature classification may be determined using Table 4.

For example, on printed circuit boards of at least 0,5 mm thickness, having a conducting track of at least 33 µm thickness on one or both sides, by applying factors given in Notes 3, 4, 8, 9 of Table 4, a temperature classification of T4 or Group I shall be given to the printed tracks if they have a minimum width of 0,3 mm and the continuous current in the tracks does not exceed 0,444 A. Similarly, for minimum track widths of 0,5 mm, 1,0 mm and 2,0 mm, T4 shall be given for corresponding maximum currents of 0,648 A, 1,092 A and 1,833 A respectively.

Track lengths of 10 mm or less shall be disregarded for temperature classification purposes.

Where temperature classification of a track is to be experimentally determined, the maximum continuous current shall be used.

Manufacturing tolerances shall not reduce the values stated in this clause by more than 10 % or 1 mm, whichever is the smaller.

In the absence of testing, where the maximum power does not exceed 1,3 W, the tracks are suitable for a temperature classification of T4 ~~or Group I~~.

~~For Group I, where dust is excluded, 3,3 W is allowable.~~

Refer to Table 2b) where a derating is required for ambient temperatures greater than 40 °C.

**Table 4 – Temperature classification of tracks on printed circuit boards  
(in a maximum ambient temperature of 40 °C)**

| Minimum track width<br>mm | Maximum permissible current for temperature classification |         |                    |
|---------------------------|------------------------------------------------------------|---------|--------------------|
|                           | T1 to T4 <del>and Group I</del><br>A                       | T5<br>A | T6<br>A            |
| 0,075                     | 0,8                                                        | 0,6     | 0,5                |
| 0,1                       | 1,0                                                        | 0,8     | 0,7                |
| 0,125                     | 1,2                                                        | 1,0     | 0,8                |
| 0,15                      | 1,4                                                        | 1,1     | 1,0                |
| 0,2                       | 1,8                                                        | 1,4     | 1,2                |
| 0,3                       | 2,4                                                        | 1,9     | <del>4,0</del> 1,7 |
| 0,4                       | 3,0                                                        | 2,4     | 2,1                |
| 0,5                       | 3,5                                                        | 2,8     | 2,5                |
| 0,7                       | 4,6                                                        | 3,5     | 3,2                |
| 1,0                       | 5,9                                                        | 4,8     | 4,1                |
| 1,5                       | 8,0                                                        | 6,4     | 5,6                |
| 2,0                       | 9,9                                                        | 7,9     | 6,9                |
| 2,5                       | 11,6                                                       | 9,3     | 8,1                |
| 3,0                       | 13,3                                                       | 10,7    | 9,3                |
| 4,0                       | 16,4                                                       | 13,2    | 11,4               |
| 5,0                       | 19,3                                                       | 15,5    | 13,5               |
| 6,0                       | 22,0                                                       | 17,7    | 15,4               |

NOTE 1 The value given for maximum permissible current in amperes is the r.m.s. a.c. or d.c. value.

NOTE 2 This table applies to printed boards 1,6 mm or thicker with a single layer of copper of 33 µm thickness.

NOTE 3 For boards with a thickness between 0,5 mm and 1,6 mm, divide the maximum current specified by 1,2.

NOTE 4 For boards with conducting tracks on both sides, divide the maximum current specified by 1,5.

NOTE 5 For multilayer boards, for the track layer under consideration, divide the maximum current specified by 2.

NOTE 6 For 18 µm copper thickness, divide the maximum current by 1,5.

NOTE 7 For 70 µm copper thickness, multiply the maximum current by 1,3.

NOTE 8 For tracks passing under components dissipating 0,25 W or more either normally or under fault conditions, divide the maximum current specified by 1,5.

NOTE 9 At terminations of components dissipating 0,25 W or more either normally or under fault conditions, and for 1,00 mm along the conductor, either multiply the track width by 3 or divide the maximum current specified by 2. If the track goes under the component, apply the factor specified in note 8 in addition.

NOTE 10 For ambient temperature up to 60 °C, divide the maximum current by 1,2.

NOTE 11 For ambient temperature up to 80 °C, divide the maximum current by 1,3.

## 5.7 Simple apparatus

The following apparatus shall be considered to be simple apparatus:

- a) passive components, for example switches, junction boxes, resistors and simple semiconductor devices;
- b) sources of stored energy consisting of single components in simple circuits with well-defined parameters, for example capacitors or inductors, whose values shall be considered when determining the overall safety of the system;
- c) sources of generated energy, for example thermocouples and photocells, which do not generate more than 1,5 V, 100 mA and 25 mW.

Simple apparatus shall conform to all relevant requirements of this standard. The manufacturer or intrinsically safe system designer shall demonstrate compliance with this clause, including material data sheets and test reports, if applicable. The apparatus need not comply with Clause 12.

The following aspects shall always be considered:

- 1) simple apparatus shall not achieve safety by the inclusion of voltage and/or current-limiting and/or suppression devices;
- 2) simple apparatus shall not contain any means of increasing the available voltage or current, for example DC-DC converters;
- 3) where it is necessary that the simple apparatus maintains the integrity of the isolation from earth of the intrinsically safe circuit, it shall be capable of withstanding the test voltage to earth in accordance with 6.3.12. Its terminals shall conform to 6.2.1;
- 4) non-metallic enclosures and enclosures containing light metals when located in the explosive gas atmosphere shall conform to 7.3 and 8.1 of ANSI/ISA-60079-0 ~~IEC 60079-0~~;
- 5) when simple apparatus is located in the explosive gas atmosphere, it shall be temperature classified. When used in an intrinsically safe circuit within their normal rating and at a maximum ambient temperature of 40 °C, switches, plugs, sockets and terminals will have a maximum surface temperature of less than 85 °C, so they can be allocated a T6 temperature classification for Group II applications ~~and are also suitable for Group I applications~~. Other types of simple apparatus shall be temperature classified in accordance with Clause 4 of this standard.

Where simple apparatus forms part of an apparatus containing other electrical circuits, the whole shall be assessed according to the requirements of this standard.

NOTE 1 Sensors which utilize catalytic reaction or other electro-chemical mechanisms are not normally simple apparatus. Specialist advice on their application should be sought.

NOTE 2 It is not a requirement of this standard that the conformity of the manufacturer's specification of the simple apparatus needs to be verified.

## 6 Apparatus construction

NOTE The requirements given in this clause apply, unless otherwise stated in the relevant subclauses, only to those features of intrinsically safe apparatus and associated apparatus which contribute to this type of protection.

For example, the requirements for encapsulation with casting compound apply only if encapsulating is required to satisfy 6.3.4 or 6.6.

## 6.1 Enclosures

Where intrinsic safety can be impaired by access to conducting parts, for example if the circuits contain infallible creepage distances, an enclosure is necessary.

The degree of protection required will vary according to the intended use; ~~for example, a degree of protection of IP54 in accordance with IEC 60529 may be required for Group I apparatus.~~

The "enclosure" need not be physically the same for protection against contact with live parts and the ingress of solid foreign bodies and liquids.

The designation of the surfaces which form the boundaries of the enclosure shall be the responsibility of the manufacturer and shall be recorded in the definitive documentation (see Clause 13).

### 6.1.1 Apparatus complying with Table 5

Apparatus meeting the separation requirements of Table 5 shall be provided with an enclosure meeting the requirements of IP20 or greater.

The enclosure does not need to be subjected to the tests for enclosures in 26.4 of ANSI/ISA-60079-0 ~~IEC 60079-0~~; however, the drop test 26.4.3 of ANSI/ISA-60079-0 ~~IEC 60079-0~~ still applies.

### 6.1.2 Apparatus complying with Annex F

Apparatus meeting the separation requirements of Annex F shall be provided with protection to achieve pollution degree 2. This can be achieved by:

- a) an enclosure meeting the requirements of IP54 or greater in accordance with IEC 60529. The enclosure shall be subjected to the tests for enclosures in 26.4 of ANSI/ISA-60079-0 ~~IEC 60079-0~~.
- b) an enclosure meeting the requirements of IP20 or greater in accordance with IEC 60529 provided that separations are obtained by using coating type 1 or type 2. The enclosure does not need to be subjected to the tests for enclosures in 26.4 of ANSI/ISA-60079-0 ~~IEC 60079-0~~.
- c) installation, provided that requirements shall be specified as special conditions for safe use and the apparatus shall be marked ~~with the symbol X~~ according to item i) of 29.2 of ANSI/ISA-60079-0 ~~IEC 60079-0~~.

## 6.2 Facilities for connection of external circuits

### 6.2.1 Terminals

In addition to satisfying the requirements of Table 5, terminals for intrinsically safe circuits shall be separated from terminals for non-intrinsically safe circuits by one or more of the methods given in a) or b).

These methods of separation shall also be applied where intrinsic safety can be impaired by external wiring which, if disconnected from the terminal, can come into contact with conductors or components.

NOTE 1 Terminals for connection of external circuits to intrinsically safe apparatus and associated apparatus should be so arranged that components will not be damaged when making the connections.

- a) When separation is accomplished by distance then the clearance between bare conducting parts of terminals shall be at least 50 mm.

NOTE 2 Care must be exercised in the layout of terminals and in the wiring method used so that contact between circuits is unlikely if a wire becomes dislodged.

- b) When separation is accomplished by locating terminals for intrinsically safe and non-intrinsically safe circuits in separate enclosures or by use of either an insulating partition or an earthed metal partition between terminals with a common cover, the following applies:
- 1) partitions used to separate terminals shall extend to within 1,5 mm of the enclosure walls, or alternatively shall provide a minimum distance of 50 mm between the bare conducting parts of terminals when measured in any direction around the partition;
  - 2) metal partitions shall be earthed and shall have sufficient strength and rigidity to ensure that they are not likely to be damaged during field wiring. Such partitions shall be at least 0,45 mm thick or shall conform to 10.6.3 if of lesser thickness. In addition, metal partitions shall have sufficient current-carrying capacity to prevent burn-through or loss of earth connection under fault conditions;
  - 3) non-metallic insulating partitions shall have an appropriate CTI, sufficient thickness and shall be so supported that they cannot readily be deformed in a manner that would defeat their purpose. Such partitions shall be at least 0,9 mm thick, or shall conform to 10.6.3 if of lesser thickness.

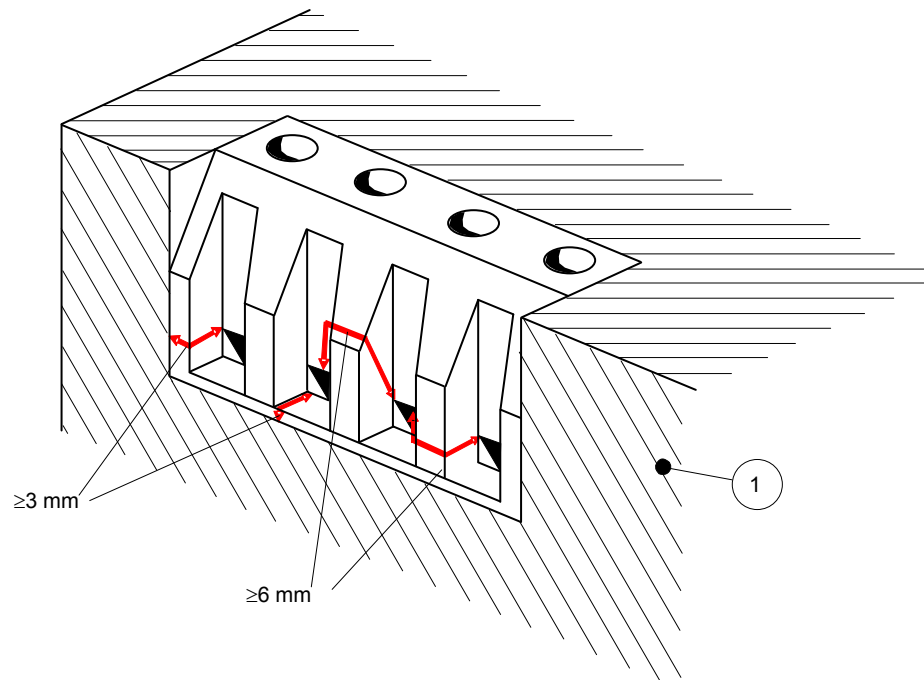
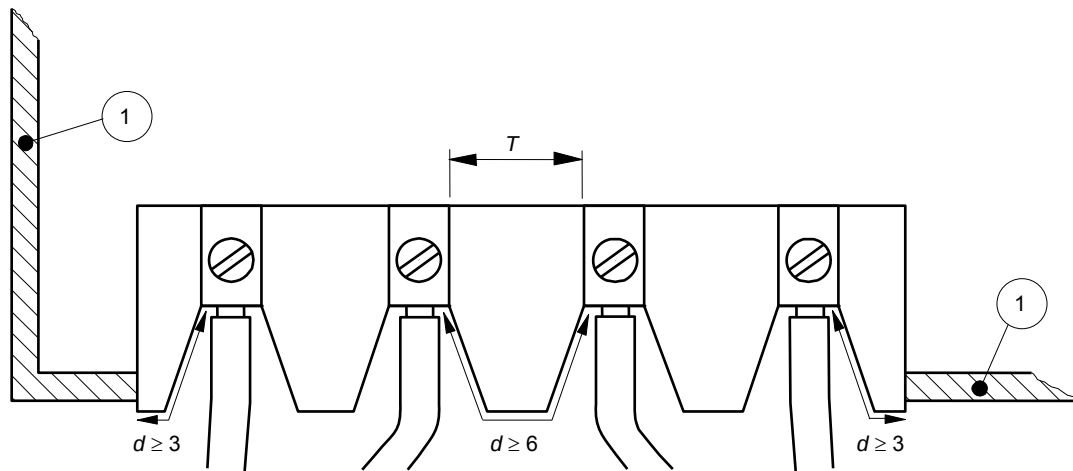
The clearances and creepage distances between the bare conducting parts of terminals of separate intrinsically safe circuits and to earthed or potential-free conducting parts shall be equal to or exceed the values given in Table 5.

Where separate intrinsically safe circuits are being considered, the clearance distance between bare conducting parts of external connection facilities shall meet the following:

- at least 6 mm between the separate intrinsically safe circuits;
- at least 3 mm from earthed parts, if connection to earth has not been considered in the safety analysis.

See Figure 1 when measuring distances around solid insulating walls or partitions. Any possible movement of metallic parts that are not rigidly fixed shall be taken into account.

Dimensions in millimetres



IEC 1380/06

**Key**

1 Conductive cover

 $T$  Distances in accordance with Table 5 $d$  Clearance distance at external connection facilities of terminals in accordance with 6.2.1

NOTE The dimensions shown are the creepage and clearance distances around the insulation as indicated above, not the thickness of the insulation.

**Figure 1a – Distance requirements for terminals carrying separate intrinsically safe circuits**



### 6.2.3 Determination of maximum external inductance to resistance ratio ( $L_o/R_o$ ) for resistance limited power source

The maximum external inductance to resistance ratio ( $L_o/R_o$ ) which may be connected to a resistance limited power source shall be calculated using the following formula. This formula takes account of a 1,5 factor of safety on current and shall not be used where  $C_s$  for the output terminals of the apparatus exceeds 1 % of  $C_o$ .

$$\frac{L_o}{R_o} = \frac{8eR_s + (64e^2R_s^2 - 72U_o^2 eL_s)^{1/2}}{4,5 U_o^2} \text{ H}/\Omega$$

where

$e$  is the minimum spark-test apparatus ignition energy in joules, and is for

|                               |                                  |
|-------------------------------|----------------------------------|
| <del>Group I apparatus:</del> | <del>525 <math>\mu</math>J</del> |
| – Group IIA apparatus:        | 320 $\mu$ J                      |
| – Group IIB apparatus:        | 160 $\mu$ J                      |
| – Group IIC apparatus:        | 40 $\mu$ J                       |

$R_s$  is the minimum output resistance of the power source, in ohms;

$U_o$  is the maximum open circuit voltage, in volts;

$L_s$  is the maximum inductance present at the power source terminals, in henries.

$C_s$  is the maximum capacitance present at the power source terminals, in farads

If  $L_s = 0$

then

$$\frac{L_o}{R_o} = \frac{32eR_s}{9U_o^2} \text{ H}/\Omega$$

Where a safety factor of 1 is required, this value for  $L_o/R_o$  shall be multiplied by 2,25.

NOTE 1 The normal application of the  $L_o/R_o$  ratio is for distributed parameters, for example cables. Its use for lumped values for inductance and resistance requires special consideration.

NOTE 2  $L_o/R_o$  may be determined experimentally for non-linear power sources by testing the circuit with several discrete values of  $L_o$  and  $R_o$  using the spark tests in 10.1. The values of  $R_o$  used should range from practically a short circuit (maximum  $I_o$ ) to practically open circuit ( $I_o$  nearly zero) and a trend established that ensures that the  $L_o/R_o$  will not result in failure of the spark test.

### 6.2.4 Permanently connected cable

Apparatus which is constructed with an integral cable for external connections shall be subjected to the pull test in 10.9 on the cable if breakage of the terminations inside the apparatus could result in intrinsic safety being invalidated, for example where there is more than one intrinsically safe circuit in the cable and breakage could lead to an unsafe interconnection.

## 6.3 Separation distances

Requirements for separation distances are given in 6.3.1 to 6.3.13. An alternative method for the dimensioning of separation distances is given in Annex F.

### 6.3.1 Separation of conductive parts

Separation of conductive parts between

- intrinsically safe and non-intrinsically safe circuits, or
- different intrinsically safe circuits, or
- a circuit and earthed or isolated metal parts,

shall conform to the following if the type of protection depends on the separation.

Separation distances shall be measured or assessed taking into account any possible movement of the conductors or conductive parts. Manufacturing tolerances shall not reduce the distances by more than 10 % or 1 mm, whichever is the smaller.

Separation distances that comply with the values in 6.1.1 or 6.1.2 shall not be subject to a fault.

Separation requirements shall not apply where earthed metal, for example tracks of a printed circuit board or a partition, separates an intrinsically safe circuit from other circuits, provided that breakdown to earth does not adversely affect the type of protection and that the earthed conductive part can carry the maximum current that would flow under fault conditions.

NOTE 1 For example, the type of protection does depend on the separation to earthed or isolated metallic parts if a current-limiting resistor can be bypassed by short-circuits between the circuit and the earthed or isolated metallic part.

An earthed metal partition shall have strength and rigidity so that it is unlikely to be damaged and shall be of sufficient thickness and of sufficient current-carrying capacity to prevent burn-through or loss of earth under fault conditions. A partition either shall be at least 0,45 mm thick and attached to a rigid, earthed metal portion of the device, or shall conform to 10.6.3 if of lesser thickness.

Where a non-metallic insulating partition having a thickness and appropriate CTI in accordance with Table 5 is placed between the conductive parts, the clearances, creepage distances and other separation distances either shall be measured around the partition provided that the partition has a thickness of at least 0.9 mm, or shall conform to 10.6.3 if of lesser thickness.

NOTE 2 Methods of assessment are given in Annex C.

#### 6.3.1.1 Distances according to Table 5

For levels of protection “ia” and “ib”, smaller separation distances, which are less than the values specified in Table 5 but greater than or equal to one-third of that value, shall be considered as subject to countable short-circuit faults if this impairs intrinsic safety.

For levels of protection “ia” and “ib”, if separation distances are less than one-third of the values specified in Table 5, they shall be considered as subject to non-countable short-circuit faults if this impairs intrinsic safety.

For level of protection “ic”, if separation distances are less than the values specified in Table 5, they shall be considered as short-circuits if this impairs intrinsic safety.

### 6.3.1.2 Distances according to Annex F

For levels of protection “ia” and “ib”, if separation distances are less than the values specified in Annex F, they shall be considered as subject to non-countable short-circuit faults if this impairs intrinsic safety.

For level of protection “ic”, if separation distances are less than the values specified in Annex F, they shall be considered as short-circuits if this impairs intrinsic safety.

The fault mode of failure of segregation shall only be a short-circuit.

~~Separation requirements shall not apply where earthed metal, for example tracks of a printed circuit board or a partition, separates an intrinsically safe circuit from other circuits, provided that breakdown to earth does not adversely affect the type of protection and that the earthed conductive part can carry the maximum current that would flow under fault conditions.~~

~~NOTE 1 For example, the type of protection does depend on the separation to earthed or isolated metallic parts if a current limiting resistor can be bypassed by short circuits between the circuit and the earthed or isolated metallic part.~~

~~An earthed metal partition shall have strength and rigidity so that it is unlikely to be damaged and shall be of sufficient thickness and of sufficient current carrying capacity to prevent burn-through or loss of earth under fault conditions. A partition either shall be at least 0,45 mm thick and attached to a rigid, earthed metal portion of the device, or shall conform to 10.6.3 if of lesser thickness.~~

~~Where a non-metallic insulating partition having an appropriate CTI is placed between the conductive parts, the clearances, creepage distances and other separation distances either shall be measured around the partition provided that the partition has a thickness of at least 0,9 mm, or shall conform to 10.6.3 if of lesser thickness.~~

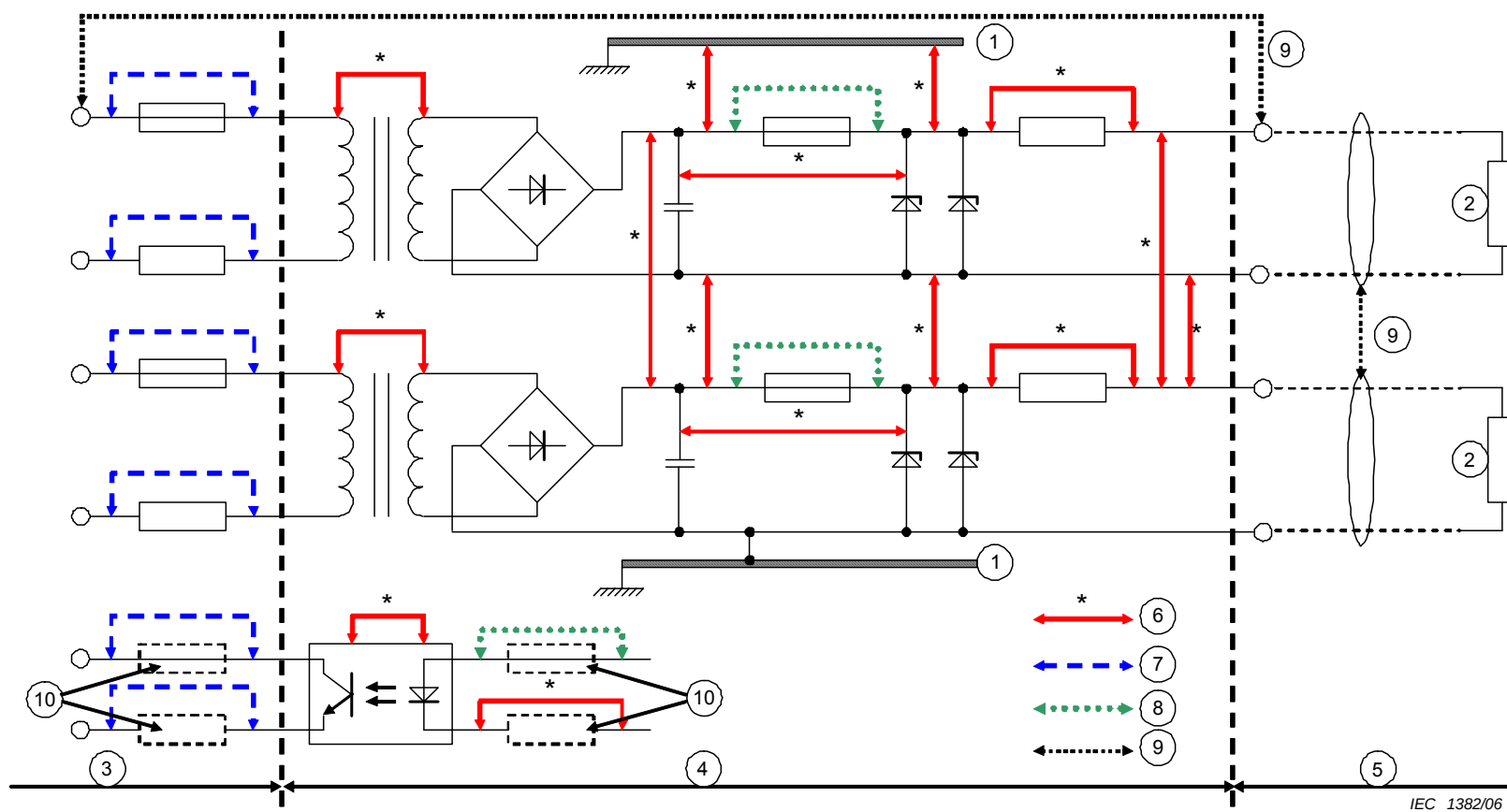
~~NOTE 2 Methods of assessment are given in Annex C.~~

Table 5 – Clearances, creepage distances and separations

| 1                                   | 2                   |      | 3                                                            |     | 4                                                            |     | 5                           |       | 6                                   |     | 7                                   |        |
|-------------------------------------|---------------------|------|--------------------------------------------------------------|-----|--------------------------------------------------------------|-----|-----------------------------|-------|-------------------------------------|-----|-------------------------------------|--------|
| Voltage<br>(peak<br>value)<br><br>V | Clearance<br><br>mm |      | Separation distance<br>through<br>casting compound<br><br>mm |     | Separation distance<br>through solid<br>insulation<br><br>mm |     | Creepage distance<br><br>mm |       | Distance<br>under coating<br><br>mm |     | Comparative tracking<br>index (CTI) |        |
| Level of<br>protection              | ia, ib              | ic   | ia, ib                                                       | ic  | ia, ib                                                       | ic  | ia, ib                      | ic    | ia, ib                              | ic  | ia                                  | ib, ic |
| 10                                  | 1,5                 | 0,4  | 0,5                                                          | 0,2 | 0,5                                                          | 0,2 | 1,5                         | 1,0   | 0,5                                 | 0,3 | -                                   | -      |
| 30                                  | 2,0                 | 0,8  | 0,7                                                          | 0,2 | 0,5                                                          | 0,2 | 2,0                         | 1,3   | 0,7                                 | 0,3 | 100                                 | 100    |
| 60                                  | 3,0                 | 0,8  | 1,0                                                          | 0,3 | 0,5                                                          | 0,3 | 3,0                         | 1,9   | 1,0                                 | 0,6 | 100                                 | 100    |
| 90                                  | 4,0                 | 0,8  | 1,3                                                          | 0,3 | 0,7                                                          | 0,3 | 4,0                         | 2,1   | 1,3                                 | 0,6 | 100                                 | 100    |
| 190                                 | 5,0                 | 1,5  | 1,7                                                          | 0,6 | 0,8                                                          | 0,6 | 8,0                         | 2,5   | 2,6                                 | 1,1 | 175                                 | 175    |
| 375                                 | 6,0                 | 2,5  | 2,0                                                          | 0,6 | 1,0                                                          | 0,6 | 10,0                        | 4,0   | 3,3                                 | 1,7 | 175                                 | 175    |
| 550                                 | 7,0                 | 4,0  | 2,4                                                          | 0,8 | 1,2                                                          | 0,8 | 15,0                        | 6,3   | 5,0                                 | 2,4 | 275                                 | 175    |
| 750                                 | 8,0                 | 5,0  | 2,7                                                          | 0,9 | 1,4                                                          | 0,9 | 18,0                        | 10,0  | 6,0                                 | 2,9 | 275                                 | 175    |
| 1 000                               | 10,0                | 7,0  | 3,3                                                          | 1,1 | 1,7                                                          | 1,1 | 25,0                        | 12,5  | 8,3                                 | 4,0 | 275                                 | 175    |
| 1 300                               | 14,0                | 8,0  | 4,6                                                          | 1,7 | 2,3                                                          | 1,7 | 36,0                        | 13,0  | 12,0                                | 5,8 | 275                                 | 175    |
| 1 575                               | 16,0                | 10,0 | 5,3                                                          | *   | 2,7                                                          | *   | 49,0                        | 15,0  | 16,3                                | *   | 275                                 | 175    |
| 3,3 k                               | *                   | 18,0 | 9,0                                                          | *   | 4,5                                                          | *   | *                           | 32,0  | *                                   | *   | *                                   | *      |
| 4,7 k                               | *                   | 22,0 | 12,0                                                         | *   | 6,0                                                          | *   | *                           | 50,0  | *                                   | *   | *                                   | *      |
| 9,5 k                               | *                   | 45,0 | 20,0                                                         | *   | 10,0                                                         | *   | *                           | 100,0 | *                                   | *   | *                                   | *      |
| 15,6 k                              | *                   | 70,0 | 33,0                                                         | *   | 16,5                                                         | *   | *                           | 150,0 | *                                   | *   | *                                   | *      |

NOTE 1 \* No values for all voltages are proposed at present.

NOTE 2 Evidence of compliance with the CTI requirements of insulating materials must be provided by the manufacturer. At voltages up to 10 V, the CTI of insulating materials is not required to be specified.



**Key**

- 1 Chassis
- 2 Load
- 3 Non-intrinsically safe circuit defined by  $U_m$
- 4 Part of intrinsically safe circuit not itself intrinsically safe
- 5 Intrinsically safe circuit
- 6 Dimensions to which Table 5 or Annex F is where applicable
- 7 Dimensions to which general industrial standards are applicable
- 8 Dimensions to 7.3
- 9 Dimensions to 6.2.1 for output terminals between separate Intrinsically safe circuits and between Intrinsically safe to non intrinsically safe circuits
- 10 If necessary

**Figure 2 – Example of separation of conducting parts**

### 6.3.2 Voltage between conductive parts

The voltage which is taken into account when using Table 5 or Annex F shall be the voltage between any two conductive parts for which the separation has an effect on the type of protection of the circuit under consideration, that is for example (see Figure 2) the voltage between an intrinsically safe circuit and

- part of the same circuit which is not intrinsically safe, or
- non-intrinsically safe circuits, or
- other intrinsically safe circuits.

The value of voltage to be considered shall be either of the following, as applicable.

- a) For circuits which are galvanically separated within the apparatus, the value of voltage to be considered between the circuits, shall be the highest voltage that can appear across the separation when the two circuits are connected together at any one point, derived from
- the rated voltages of the circuits, or
  - the maximum voltages specified by the manufacturer which may safely be supplied to the circuits, or
  - any voltages generated within the same apparatus.

Where one of the voltages is less than 20 % of the other, it shall be ignored. Mains supply voltages shall be taken without the addition of standard mains tolerances. For such sinusoidal voltages, peak voltage shall be considered to be the following:

$\sqrt{2} \times \text{r.m.s. value of the rated voltage.}$

- b) Between parts of a circuit: the maximum peak value of the voltage that can occur in either part of that circuit. This may be the sum of the voltages of different sources connected to that circuit. One of the voltages may be ignored if it is less than 20 % of the other.

In all cases voltages which arise during the fault conditions of Clause 5 shall, where applicable, be used to derive the maximum.

Any external voltage shall be assumed to have the value  $U_m$  or  $U_i$  declared for the connection facilities through which it enters. Transient voltages such as might exist before a protective device, for example a fuse, opens the circuit shall not be considered when evaluating the creepage distance, but shall be considered when evaluating clearances.

### 6.3.3 Clearance

In measuring or assessing clearances between conductive parts, insulating partitions of less than 0,9 mm thickness, or which do not conform to 10.6.3, shall be ignored. Other insulating parts shall conform to column 4 of Table 5 or column 2 of Table F.1 and column 2 of Table F.2 where applicable.

For voltages higher than 1 575 V peak, an interposing insulating partition or earthed metal partition shall be used. In either case, the partition shall conform to 6.3.1.

### 6.3.4 Separation distances through casting compound

Casting compound shall meet the requirements of 6.6. For those parts that require encapsulation, the minimum separation distance between encapsulated conductive parts and

components, and the free surface of the casting compound shall be at least half the values shown in column 3 of Table 5, with a minimum of 1 mm, or column 3 of Table F.1 and column 3 of Table F.2 where applicable. When the casting compound is in direct contact with and adheres to an enclosure of insulating material conforming to column 4 of Table 5, no other separation is required (see Figure D.1).

The insulation of the encapsulated circuit shall conform to 6.3.12.

The failure of a component which is encapsulated or hermetically sealed, for example a semiconductor, which is used in accordance with 7.1 and in which internal clearances and distances through encapsulant are not defined, is to be considered as a single countable fault.

NOTE Further guidance is given in Annex D.

### 6.3.5 Separation distances through solid insulation

Solid insulation is insulation which is extruded or moulded but not poured. It shall have a dielectric strength that conforms to 6.3.12 when the separation distance is in accordance with Table 5 or Annex F. The maximum current in the insulated wiring shall not exceed the rating specified by the manufacture of the wire.

NOTE 1 If the insulator is fabricated from two or more pieces of electrical insulating material which are solidly bonded together, then the composite may be considered as solid.

NOTE 2 For the purpose of this standard, solid insulation is considered to be prefabricated, for example sheet or sleeving or elastomeric insulation on wiring.

NOTE 3 Varnish and similar coatings are not considered to be solid insulation.

### 6.3.6 Composite separations

Where separations complying with Table 5 are composite, for example through a combination of air and insulation, the total separation shall be calculated on the basis of referring all separations to one column of Table 5. For example at 60 V:

clearance (column 2) =  $6 \times$  separation through solid insulation (column 4);

clearance (column 2) =  $3 \times$  separation through casting compound (column 3);

equivalent clearance = actual clearance +  $(3 \times$  any additional separation through encapsulant) +  $(6 \times$  any additional separation through solid insulation).

For levels of protection “ia” and “ib”, for the separation to be infallible, the above result shall be not less than the clearance value specified in Table 5.

Any clearance or separation which is below one-third of the relevant value specified in Table 5 shall be ignored for the purpose of calculation.

For level of protection “ic”, the above results shall not be less than the clearance value specified in Table 5.

### 6.3.7 Creepage distance

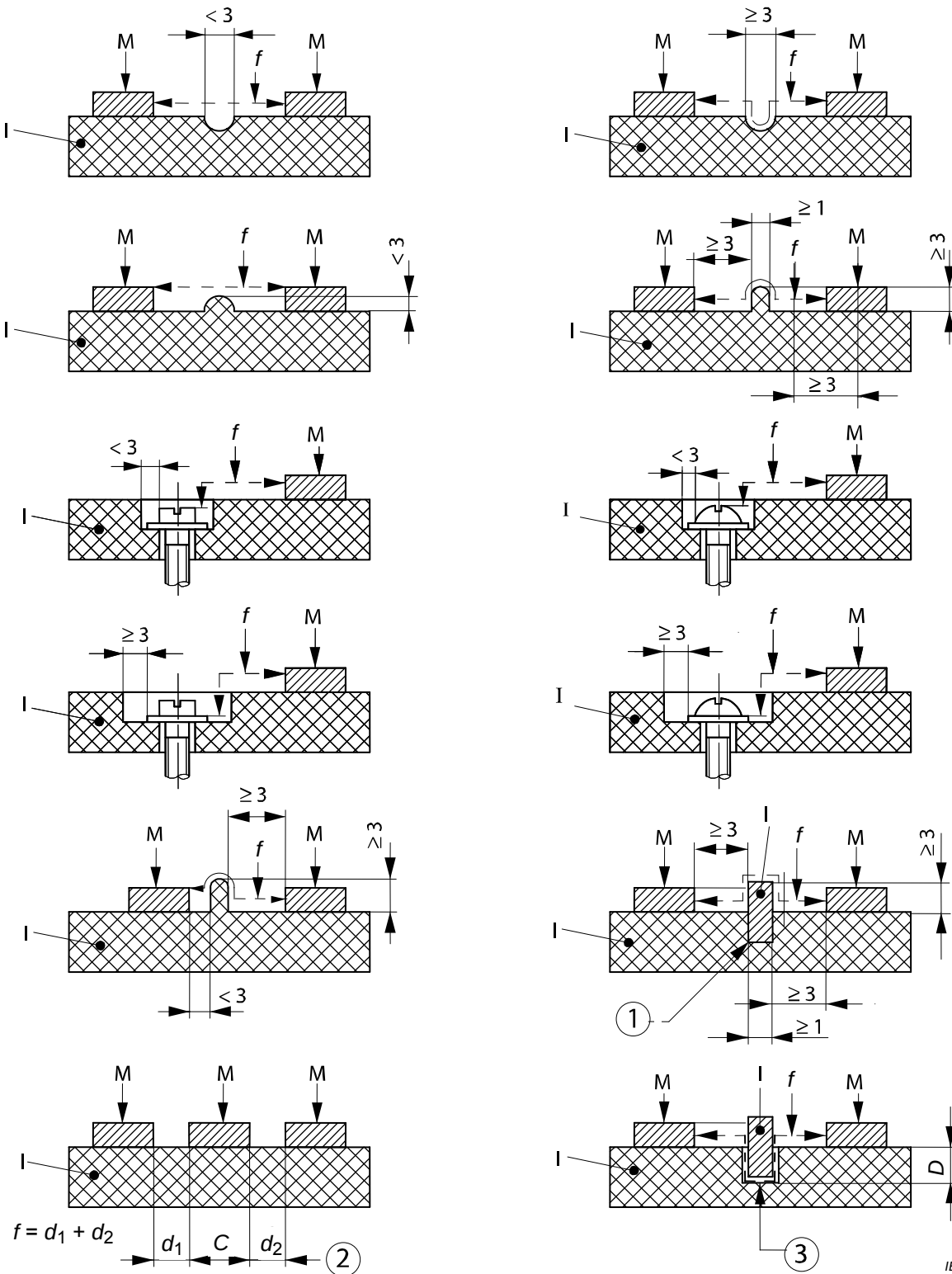
For the creepage distances specified in column 5 of Table 5 or Columns 2 of Table F.1 and column 5 of Table F.2 where applicable, the insulating material shall conform to column 7 of Table 5 or material Group IIIa or IIIb in accordance with IEC 60664-1, which specifies the minimum comparative tracking index (CTI) measured in accordance with IEC 60112 or ANSI/UL

746A. The method of measuring or assessing these distances shall be in accordance with Figure 3.

Where a joint is cemented, the cement shall have insulation properties equivalent to those of the adjacent material.

Where the creepage distance is made up from the addition of shorter distances, for example where a conductive part is interposed, distances of less than one-third the relevant value in column 5 of Table 5 shall not be taken into account. For voltages higher than 1 575 V peak, an interposing insulating partition or earthed metallic partition shall be used. In either case, the partition shall conform to 6.3.1.

UNOFFICIAL DRAFT



IEC 1383/06