

# ANSI/ISA-60079-11 (12.02.01)-2002

(Formerly ANSI/ISA-12.02.01-2002 (IEC 60079-11 Mod))

Supercedes ISA-12.02.01-1999 (IEC 60079-11 Mod)



## Electrical Apparatus for Use in Class I, Zones 0, 1, and 2 Hazardous (Classified) Locations – Intrinsic Safety "i"

Second Printing 15 July 2005

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Approved 26 February 2003



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This ANSI/UL Standard for Safety, which consists of the first edition, is under continuous maintenance, whereby each revision is ANSI approved upon publication. Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Written comments are to be sent to the UL-RTP Standards Department, 12 Laboratory Drive, Research Triangle Park, NC 27709.

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Revisions of this standard will be made by issuing revised or additional pages bearing their date of issue. A UL standard is current only if it incorporates the most recently adopted revisions, all of which are itemized on the transmittal notice that accompanies the latest set of revised requirements.

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*First Edition*

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ANSI/UL 60079-11  
*First Edition*



**ISA—The Instrumentation, Systems,  
and Automation Society**



**Electrical Apparatus for Use in Class I, Zones 0, 1, & 2  
Hazardous (Classified) Locations —  
Intrinsic Safety "i"**

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## General Notes

This is the common ISA and UL Standard for Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic Safety “i”. It is the first edition of ANSI/ISA-60079-11 [formerly ANSI/ISA-12.02.01-1999 (IEC 60079-11 Mod)] and the first edition of UL 60079-11. The ISA suffix “Mod” indicates the document is a modification of the IEC document and includes U.S. deviations encompassing both additions and deletions of information.

ANSI/ISA-60079-11 and UL 60079-11 contain identical requirements, and concurrent publication dates that align with each organization's ANSI accreditation approval processes. The presentation and format of the standards material may differ between the two published standards.

This common Standard was prepared by ISA — The Instrumentation, Systems, and Automation Society and Underwriters Laboratories Inc. (UL).

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 2 December 2002 all products Listed or Recognized by UL must comply with the requirements in this Standard.

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## Preface

This preface, as well as all footnotes and annexes, is included for information purposes and is not part of ANSI/ISA-60079-11.

This document has been prepared as part of the service of ISA—The Instrumentation, Systems, and Automation Society—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.

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This standard was approved for publication by the ISA Standards and Practices Board on 22 November 2002.

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## Foreword (UL)

A. This Standard contains basic requirements for products covered by Underwriters Laboratories Inc. (UL) under its Follow-Up Service for this category within the limitations given below and in the Scope section of this Standard. These requirements are based upon sound engineering principles, research, records of tests and field experience, and an appreciation of the problems of manufacture, installation, and use derived from consultation with and information obtained from manufacturers, users, inspection authorities, and others having specialized experience. They are subject to revision as further experience and investigation may show is necessary or desirable.

B. The observance of the requirements of this Standard by a manufacturer is one of the conditions of the continued coverage of the manufacturer's product.

C. A product which complies with the text of this Standard will not necessarily be judged to comply with the Standard if, when examined and tested, it is found to have other features which impair the level of safety contemplated by these requirements.

D. A product that contains features, characteristics, components, materials, or systems new or different from those covered by the requirements in this standard, and that involves a risk of fire or of electric shock or injury to persons shall be evaluated using appropriate additional component and end-product requirements to maintain the level of safety as originally anticipated by the intent of this standard. A product whose features, characteristics, components, materials, or systems conflict with specific requirements or provisions of this standard does not comply with this standard. Revision of requirements shall be proposed and adopted in conformance with the methods employed for development, revision, and implementation of this standard.

E. UL, in performing its functions in accordance with its objectives, does not assume or undertake to discharge any responsibility of the manufacturer or any other party. The opinions and findings of UL represent its professional judgment given with due consideration to the necessary limitations of practical operation and state of the art at the time the Standard is processed. UL shall not be responsible to anyone for the use of or reliance upon this Standard by anyone. UL shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation of, or reliance upon this Standard.

F. Many tests required by the Standards of UL are inherently hazardous and adequate safeguards for personnel and property shall be employed in conducting such tests.

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## National Differences

### GENERAL

In the UL publication of this standard, National Differences from the text of International Electrotechnical Commission (IEC) Publication 60079-11, Electrical apparatus for explosive gas atmospheres – Part 11: Intrinsic Safety "i", copyright 1999, are indicated by notations (differences) and are presented in bold text. The national difference type is included in the body.

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 standard may not include all types of these National Differences.

NOTE 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.

**DR** – These are National Differences based on the National Electrical Code (NEC) and other U.S. Regulatory Requirements.

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

**D2** – These are National Differences based on **safety practices**. These are differences for IEC requirements that may be acceptable, but adopting the IEC requirements would require considerable retesting or redesign on the manufacturer's part.

**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**.

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## Foreword (ISA)

All text of IEC 60079-11 is included in this document. U.S. National Deviations are shown by ~~strikeout~~ through deleted text and underline under 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 "Figure X Deleted." All added tables are numbered by a table number corresponding to the applicable sub-clause for improved clarity and are NOT underlined. Notes appear in the table titles showing the tables as added material. There are five annexes in this standard. Annexes C, E, F and G are informative and are not considered part of this standard.

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# 1 Scope

1.1 This standard part of IEC 60079 specifies the construction and testing of intrinsically safe apparatus, intended for use in potentially explosive atmospheres and for associated apparatus, which is intended for connection to intrinsically safe circuits which enter such atmospheres. It also contains details of the test apparatus previously published as IEC 60079-3.

1.2 This standard supplements ANSI/ISA-60079-0 IEC 60079-0:1998, the requirements of which apply to intrinsically safe apparatus and to associated apparatus except as indicated in the following list.

If associated apparatus is protected by a type of protection listed in ANSI/ISA-60079-0 IEC 60079-0 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. The list of exclusions which follows is directly applicable to associated apparatus intended for use in situations where there is no potentially explosive atmosphere and in other circumstances should be used in combination with the requirements of the other methods of protection.

| Clause of <u>ANSI/ISA-60079-0 IEC 60079-0:1998</u> |                                                          | Clause excluded              |                      |
|----------------------------------------------------|----------------------------------------------------------|------------------------------|----------------------|
|                                                    |                                                          | Intrinsically safe apparatus | Associated apparatus |
| 3.1                                                | Electrical apparatus                                     | Yes                          | Yes                  |
| 4.2.2                                              | Marking of maximum surface temperature                   | No                           | Yes                  |
| 5.1                                                | Maximum surface temperature                              | No                           | Yes                  |
| 5.3                                                | Surface temperature and ignition temperature             | No                           | Yes                  |
| 6.2                                                | Enclosure opening delay                                  | Yes                          | Yes                  |
| 7.1.1                                              | Definition of plastics material                          | No                           | Yes                  |
| 7.1.2                                              | Requirement of plastics material                         | Yes                          | Yes                  |
| 7.1.3                                              | Verification of plastics material compliance             | No                           | Yes                  |
| 7.2                                                | Thermal endurance                                        | Yes                          | Yes                  |
| 7.3                                                | Electrostatic charges on plastics enclosures             | No                           | Yes                  |
| <del>7.3.1</del>                                   | <del>Electrical apparatus of Group I</del>               | <del>Yes</del>               | <del>Yes</del>       |
|                                                    | <del>(notes 1 and 2 only)</del>                          |                              |                      |
| 7.3.2                                              | Electrical apparatus of Group II                         | Yes                          | Yes                  |
|                                                    | (notes 1 and 2 only)                                     |                              |                      |
| 7.4                                                | Threaded holes in plastics                               | Yes                          | Yes                  |
| 8.1                                                | Light metal enclosure materials                          | No                           | Yes                  |
| 8.2                                                | Threaded holes in light metals                           | Yes                          | Yes                  |
| 9                                                  | Fasteners                                                | Yes                          | Yes                  |
| 10                                                 | Interlocking devices                                     | Yes                          | Yes                  |
| 11                                                 | Bushings                                                 | Yes                          | Yes                  |
| 12                                                 | Materials used for cementing                             | Yes                          | Yes                  |
| 14                                                 | Connection facilities and terminal compartments          | Yes                          | Yes                  |
| 15                                                 | Connection facilities for earthing or bonding conductors | Yes                          | Yes                  |

| Clause of <del>ANSI/ISA-60079-0 IEC 60079-0 1998</del> |                                                                         | Clause excluded              |                      |
|--------------------------------------------------------|-------------------------------------------------------------------------|------------------------------|----------------------|
|                                                        |                                                                         | Intrinsically safe apparatus | Associated apparatus |
| 16                                                     | Cable and conduit entries                                               | Yes                          | Yes                  |
| 17 to 22                                               | Supplementary requirements for certain electrical apparatus             | Yes                          | Yes                  |
| 23.4.3.1                                               | Test for resistance to impact                                           | Yes                          | Yes                  |
| 23.4.3.2                                               | Drop test (no prior impact test necessary)                              | No                           | Yes                  |
| 23.4.3.3                                               | Required results                                                        | No                           | Yes                  |
| 23.4.5                                                 | Torque test for bushings                                                | Yes                          | Yes                  |
| 23.4.6.1                                               | Temperature measurement                                                 | No                           | Yes                  |
| 23.4.6.2                                               | Thermal shock test                                                      | Yes                          | Yes                  |
| 23.4.7.1 to 23.4.7.5 and 23.4.7.7                      | Tests on non-metallic enclosures                                        | Yes                          | Yes                  |
| 23.4.7.8                                               | Insulation resistance test of parts of enclosures of plastics materials | No                           | Yes                  |
| 27.7                                                   | Examples of marking                                                     | Yes                          | Yes                  |
| Annex B                                                | Ex cable entries                                                        | Yes                          | Yes                  |

1.3 This standard is applicable to electrical apparatus in which the electrical circuits themselves are incapable of causing an explosion in the surrounding explosive atmospheres.

1.4 This standard is also applicable to electrical apparatus or parts of electrical apparatus located outside the potentially explosive 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 potentially explosive atmosphere may depend upon the design and construction of such electrical apparatus or parts of such electrical apparatus. The electrical circuits exposed to the potentially explosive atmosphere are evaluated for use in such an atmosphere by applying this standard.

## 2 Normative References

The following ~~normative~~ documents contain provisions, which, through reference in this text, constitute provisions of this standard part of IEC 60079. At the time of publication, the editions indicated were valid. All ~~normative~~ documents are subject to revision, and parties to agreements based on this standard part of IEC 60079 are encouraged to investigate the possibility of applying the most recent editions of the ~~normative~~ documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards

ANSI/ISA-60079-0 (12.00.01) IEC 60079-0: 1998, Electrical apparatus for use in Class I, Zones 0, 1 & 2 Hazardous (Classified) Locations explosive atmospheres—Part 0: General requirements

ANSI/ISA-60079-7 (12.16.01) IEC 60079-7: 1990, Electrical apparatus for Use in Class I, Zone 1 Hazardous (Classified) Locations : Increased safety 'e'

IEC 60085: 1984, Thermal evaluation and classification of electrical insulation

IEC 60112: 1979, Method for determining the comparative and the proof-tracking indices of solid insulating materials under moist conditions

IEC 60127-1: 1988, Miniature fuses - Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links

IEC 60127-2: 1989, Miniature fuses - Part 2: Cartridge fuse links

IEC 60127-3: 1988, Miniature fuses - Part 3: Sub-miniature fuse links

IEC 60529: 1989, Degrees of protection provided by enclosures (IP Code)

UL 248-1: 2000, Low-Voltage Fuses - Part 1: General Requirements

### 3 Definitions

For the purpose of this standard the definitions in ANSI/ISA-60079-0 ~~IEC 60079-0~~ and the following definitions apply:

**3.1 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.

**3.2 electrical apparatus:**  
assembly of electrical components, electrical circuits or parts of electrical circuits normally contained in a single enclosure.

NOTE 1 The term 'normally' has been introduced to indicate that an apparatus may occasionally be in more than one enclosure, for example, a telephone or a radio transceiver with a hand microphone.

NOTE 2 This definition is more precise than that contained in ANSI/ISA-60079-0 ~~IEC 60079-0~~.

**3.3 intrinsically safe apparatus:**  
electrical apparatus in which all the circuits are intrinsically safe circuits.

**3.4 associated apparatus:**  
electrical apparatus that 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.

NOTE Associated apparatus may be either:

- a) electrical apparatus that 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.

**3.5 normal operation:**  
operation of intrinsically safe apparatus or associated apparatus such that it conforms electrically and mechanically with the design specification produced by its manufacturer.

**3.6 fault:**  
any defect of any component, separation, insulation, or connection between components, not defined as infallible by this standard, upon which the intrinsic safety of a circuit depends.

NOTE 1 If a fault leads to consequential faults in other parts upon which the type of protection of the circuit depends, the primary and subsequent failures are considered to be a single fault.

NOTE 2 For the application of such faults, see 5.2 and 5.3.

### 3.7 countable fault:

fault which occurs in parts of intrinsically safe apparatus or associated apparatus ~~electrical apparatus~~ conforming to the constructional requirements of this standard.

### 3.8 non-countable fault:

fault that occurs in parts of intrinsically safe apparatus or associated apparatus ~~electrical apparatus~~ not conforming to the constructional requirements of this standard.

### 3.9 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 this standard.

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.

NOTE Such a component or assembly is considered as not subject to fault when assessments or tests for the type of protection are made.

### 3.10 infallible separation or insulation:

separation or insulation between electrically conductive parts that is considered as not subject to short circuits.

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 simple apparatus:

~~an 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.~~

Passive components such as light-emitting diodes (LEDs), resistors, resistance temperature detectors (RTDs), and switches. Thermocouples, and similar sources of generated energy that will not generate more than 1.5 volts, 0.1 ampere, and 25 milliwatts (NFPA 70-National Electrical Code 2002, 504-2).

### 3.12 internal wiring:

wiring and electrical connections that are made within the intrinsically safe apparatus or associated 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 minimum igniting current (MIC):

minimum current in resistive or inductive circuits that causes the ignition of the explosive test mixture in the spark-test apparatus according to Annex B.

### 3.14 minimum igniting voltage:

minimum voltage of capacitive circuits that causes the ignition of the explosive test mixture in the spark-test apparatus described in Annex B.

### 3.15 maximum r.m.s. a.c. or d.c. voltage ( $U_m$ ):

maximum voltage that can be applied to the non-intrinsically safe connection facilities of associated apparatus without invalidating intrinsic safety.

NOTE The value of  $U_m$  may be different at different sets of connection facilities and may be different for ac and dc voltages.

3.16 maximum input voltage ( $U_i$  or  $V_{max}$ ):

maximum voltage (peak a.c. or d.c.) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

3.17 maximum output voltage ( $U_o$  or  $V_{oc}$ ):

maximum output voltage (peak a.c. or d.c.) in an intrinsically safe circuit that can appear under open circuit conditions at the connection facilities of the apparatus at any applied voltage up to the maximum voltage, including  $U_m$  and  $U_i$  (or  $V_{max}$ ).

NOTE Where there is more than one applied voltage, the maximum output voltage is that occurring under the most onerous combination of applied voltages.

3.18 maximum input current ( $I_i$  or  $I_{max}$ ):

maximum current (peak a.c. or d.c.) that can be applied to the connection facilities for intrinsically safe circuits without invalidating intrinsic safety.

3.19 maximum output current ( $I_o$  or  $I_{sc}$ ):

maximum current (peak a.c. or d.c.) in an intrinsically safe circuit that can be taken from the connection facilities of the apparatus.

3.20 maximum input power ( $P_i$ ):

maximum input power in an intrinsically safe circuit that can be dissipated within an apparatus when it is connected to an external source without invalidating intrinsic safety.

3.21 maximum output power ( $P_o$ ):

maximum electrical power in an intrinsically safe circuit that can be taken from the apparatus.

3.22 maximum external capacitance ( $C_o$  or  $C_a$ ):

maximum capacitance in an intrinsically safe circuit that can be connected to the connection facilities of the associated apparatus without invalidating intrinsic safety.

3.23 maximum internal capacitance ( $C_i$ ):

total equivalent internal capacitance of the intrinsically safe apparatus that is considered as appearing across the connection facilities of the apparatus.

3.24 maximum external inductance ( $L_o$  or  $L_a$ ):

maximum value of inductance in an intrinsically safe circuit that can be connected to the connection facilities of the associated apparatus without invalidating intrinsic safety.

3.25 maximum internal inductance ( $L_i$ ):

total equivalent internal inductance of the intrinsically safe apparatus which is considered as appearing at the connection facilities of the apparatus.

3.26 maximum external inductance to resistance ratio ( $L_o/R_o$  or  $L_a/R_a$ ):

ratio of inductance ( $L_o$  or  $L_a$ ) to resistance ( $R_o$  or  $R_a$ ) of any external circuit that can be connected to the connection facilities of the associated electrical apparatus without invalidating intrinsic safety.

3.27 maximum internal inductance to resistance ratio ( $L_i/R_i$ ):

ratio of inductance ( $L_i$ ) to resistance ( $R_i$ ) which is considered as appearing at the external connection facilities of the intrinsically safe electrical apparatus.

3.28 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 that are insulated parts or covered with casting compound.

3.29 distance through casting compound:  
shortest distance through a casting compound between two conductive parts.

3.30 distance through solid insulation:  
shortest distance through solid insulation between two conductive parts.

3.31 creepage distance in air:  
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.

3.32 creepage distance under coating:  
shortest distance between conductive parts along the surface of an insulating medium covered with insulating coating.

3.33 fuse rating ( $I_n$ ):  
the current rating of a fuse according to IEC 60127 or to its manufacturer's specification.

3.34 sealed gas-tight cell or battery:  
a cell or battery that remains closed and does not release either gas or liquid when operated within the limits of charge or temperature specified by the manufacturer.

NOTE Such cells and batteries may be equipped with a safety device to prevent dangerously high internal pressure. The cell or battery does not require addition to the electrolyte and is designed to operate during its life in its original sealed state.

3.35 sealed valve regulated cell or battery:  
a cell or battery that is closed under normal conditions but has an arrangement that allows the escape of gas if the internal pressure exceeds a predetermined value. The cell or battery cannot normally receive an addition to the electrolyte.

3.36 diode safety barriers:  
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.

3.37 intrinsically safe system:  
assembly of interconnected items of apparatus that may comprise intrinsically safe apparatus, associated apparatus and other 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.

3.38 apparatus and systems of category '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.

**3.39 apparatus and systems of category 'ib':**

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

**3.40 infallible connections:**

connections, including joints and interconnecting wiring, that are not considered as becoming open-circuited in service or storage.

**3.41 control drawing:**

a drawing or other document provided by the manufacturer of the intrinsically safe or associated apparatus that details the allowed interconnections between other circuits or apparatus. If the intrinsically safe or associated apparatus is investigated under the entity concept, the control drawing shall include the applicable electrical parameters to permit selection of apparatus for interconnection.

**3.42 entity evaluation:**

a method used to determine acceptable combinations of intrinsically safe apparatus and associated apparatus that have not been investigated in such combinations.

**3.43 maximum output current - multiple channel apparatus ( $I_p$ ):**

the maximum dc or peak ac current that can be extracted from any combination of terminals of a multiple channel associated apparatus.

**3.44 maximum output voltage - multiple channel apparatus ( $V_t$  or  $U_p$ ):**

the maximum dc or peak ac open circuit voltage that can appear across any combination of terminals of a multiple channel associated apparatus.

**3.45 source resistance ( $R_s$ ):**

the minimum resistance of the power source that defines the output short-circuit current  $I_o$ .

**3.46 source capacitance ( $C_s$ ):**

the capacitance appearing at the output terminals of the power source.

**3.47 source inductance ( $L_s$ ):**

the inductance appearing at the output terminals of the power source.

**3.48 live maintenance:**

maintenance activities other than normal operation that are allowed by the manufacturer's documentation, such as calibration or programming, which are carried out while the intrinsically safe apparatus and circuits are energized.

**3.49 maximum output power:**

multiple channel apparatus ( $P_t$ ) the maximum electrical power that can be taken from any combination of terminals of a multiple-channel associated apparatus.

**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 Categories of electrical apparatus

### 5.1 General

Intrinsically safe apparatus and intrinsically safe parts of associated apparatus shall be placed in category 'ia' or 'ib'.

The requirements of this standard shall apply to both categories unless otherwise stated. In the determination of category 'ia' or 'ib' failure of components and connections shall be considered in accordance with 7.6.

NOTE Apparatus may be specified as both 'ia' and 'ib' and may have different parameters for each category.

### 5.2 Category 'ia'

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of category '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 that give the most onerous condition;
- b) in normal operation and with the application of one countable fault plus those non-countable faults that give the most onerous condition;
- c) in normal operation and with the application of two countable faults plus those non-countable faults that 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 10.4.2:

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 category 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 category 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 category 'ia' system comprising two pieces of apparatus will have up to two countable faults applied, not four.

### 5.3 Category 'ib'

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of category '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 10.4.2. 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 category of 'ib' if the test requirements for 'ib' can be satisfied.

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

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 category 'ib' system comprising two pieces of apparatus will have only one countable fault applied, not two.

#### 5.4 Simple apparatus

The following apparatus shall be considered to be simple apparatus:

- a) passive components, for example switches, junction boxes, resistors, RTDs and simple semiconductor devices LEDs;
- ~~b) sources of stored energy with well defined parameters, for example capacitors or inductors, whose values shall be considered when determining the overall safety of the system;~~
- e) sources of generated energy, for example thermocouples and photocells, which do not generate more than 1.5 V, 100 mA and 25 mW. ~~Any inductance or capacitance present in these sources of energy shall be considered as in b).~~

Simple apparatus shall conform to all relevant requirements of this standard but need not be approved certified and need not comply with Clause 12. In particular, the following aspects shall always be considered.

- a) simple apparatus shall not achieve safety by the inclusion of voltage and/or current limiting and/or suppression devices;
- b) simple apparatus shall not contain any means of increasing the available voltage or current, for example, circuits for the generation of ancillary power supplies;
- c) 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 6.4.12. Its terminals shall conform to 6.3.1;
- d) nonmetallic enclosures and enclosures containing light metals when located in the hazardous (classified) location area shall conform to 7.3 and 8.1 of ANSI/ISA-60079-0 IEC 60079-0;
- e) when simple apparatus is located in the hazardous (classified) location area, 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 and sockets, and terminals are allocated a T6 temperature classification for Group II. ~~applications and considered as having a maximum surface temperature of 85°C for Group I applications. Other types of simple apparatus shall be temperature classified in accordance with Clauses 4 and 6 of this standard.~~

Where simple apparatus forms part of an apparatus containing other electrical circuits, the whole shall be ~~certified~~ approved.

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

## 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, and they are additional to the general requirements of ANSI/ISA-60079-0 ~~IEC 60079-0~~ except for those excluded in 1.2.

For example, the requirements for encapsulation with casting compound apply only if encapsulating is required to satisfy 6.4.4 or 6.7.

### 6.1 Enclosures

In principle, intrinsically safe apparatus and associated apparatus do not require an enclosure as the method of protection is embodied within the circuits themselves. However, where intrinsic safety can be impaired by access to conducting parts, for example, if the circuits contain infallible creepage distances in air, an enclosure of at least IP 20 in accordance with IEC 60529 shall be provided as part of the apparatus under test.

The degree of protection required will vary according to the intended use; ~~for example, a degree of protection of IP 54 in accordance with IEC 60529 will in general be required for Group I apparatus.~~

The 'enclosure' may 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 that form the boundaries of the enclosure shall be the responsibility of the manufacturer and shall be recorded in the definitive documentation (see Clause 13).

### 6.2 Wiring and small component temperatures

#### 6.2.1 ~~Dust layers on Group I equipment~~

~~For the purposes of this clause where reference is made to T4 and Group I, the Group I equipment shall be equipment in which coal dust cannot form a layer in the location of or on the component being considered.~~

### 6.2.2 Wiring within apparatus

The maximum permissible current corresponding to the maximum wire temperature due to self-heating shall either be taken from Table 1 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 ( $0.004265 \text{ K}^{-1}$  for copper);

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

$I_f$  is the current at which the wire melts in an ambient temperature of  $40^\circ\text{C}$ , in amps;

$T$  is the melting temperature of the wire material in degrees Celsius ( $1083^\circ\text{C}$  for copper);

$t$  is the wire temperature due to self-heating and ambient temperature, in degrees Celsius.

The maximum current in insulated wiring shall not exceed the rating specified by the manufacturer of the wire.

**Table 1 — Temperature classification of copper wiring  
(in a maximum ambient temperature of  $40^\circ\text{C}$ )**

| Diameter<br>(see note 4)                                                                                                                                     | Cross-sectional area<br>(see note 4) | Maximum permissible current for<br>temperature classification |         |         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------------------------------------------|---------|---------|
| mm                                                                                                                                                           | mm <sup>2</sup>                      | T1 to T4 and Group I<br>A                                     | T5<br>A | T6<br>A |
| 0.035                                                                                                                                                        | 0.000962                             | 0.53                                                          | 0.48    | 0.43    |
| 0.05                                                                                                                                                         | 0.00196                              | 1.04                                                          | 0.93    | 0.84    |
| 0.1                                                                                                                                                          | 0.00785                              | 2.1                                                           | 1.9     | 1.7     |
| 0.2                                                                                                                                                          | 0.0314                               | 3.7                                                           | 3.3     | 3.0     |
| 0.35                                                                                                                                                         | 0.0962                               | 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 amps, 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 6.2.3).             |                                      |                                                               |         |         |
| NOTE 4 Diameter and cross-sectional areas are the nominal dimensions specified by the wire manufacturer.                                                     |                                      |                                                               |         |         |
| NOTE 5 Where the maximum input power $P_i$ does not exceed 1.3 W the wiring can be awarded a temperature classification of T4 and is acceptable for Group I. |                                      |                                                               |         |         |

### 6.2.3 Printed circuit wiring

On printed circuit boards of at least 0.5 mm thickness, having a conducting track of at least 35µm thickness on one or both sides, a temperature classification 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 0.518 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 0.814 A, 1.388 A and 2.222 A respectively. Track lengths of 10 mm or less shall be disregarded for temperature classification purposes.

For other applications, the temperature classification of copper wiring of printed boards shall be determined from Table 2.

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

Where the maximum input power  $P_i$  does not exceed 1.3 W, the printed wiring shall be given a temperature classification of T4 ~~or Group I~~.

**Table 2 — Temperature classification of printed board wiring  
(in a maximum ambient temperature of 40°C)**

| Minimum track width<br><br>mm | Maximum permissible current for temperature classification |         |         |
|-------------------------------|------------------------------------------------------------|---------|---------|
|                               | T1 to T4 and Group I<br>A                                  | T5<br>A | T6<br>A |
| 0.15                          | 1.2                                                        | 1.0     | 0.9     |
| 0.2                           | 1.8                                                        | 1.45    | 1.3     |
| 0.3                           | 2.8                                                        | 2.25    | 1.95    |
| 0.4                           | 3.6                                                        | 2.9     | 2.5     |
| 0.5                           | 4.4                                                        | 3.5     | 3.0     |
| 0.7                           | 5.7                                                        | 4.6     | 4.1     |
| 1.0                           | 7.5                                                        | 6.05    | 5.4     |
| 1.5                           | 9.8                                                        | 8.1     | 6.9     |
| 2.0                           | 12.0                                                       | 9.7     | 8.4     |
| 2.5                           | 13.5                                                       | 11.5    | 9.6     |
| 3.0                           | 16.1                                                       | 13.1    | 11.5    |
| 4.0                           | 19.5                                                       | 16.1    | 14.3    |
| 5.0                           | 22.7                                                       | 18.9    | 16.6    |
| 6.0                           | 25.8                                                       | 21.8    | 18.9    |

NOTE 1 The value given for maximum permissible current in amps 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 35 µm thickness.

NOTE 3 For boards with a thickness of > 0.5 mm to < 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 Where 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.

#### 6.2.4 Small components

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

- when tested in accordance with 10.7, small components shall not cause ignition of the flammable mixture, and any deformation or deterioration caused by the higher temperature shall not impair the type of protection;
- for T4 and Group I classification, small components shall conform to Table 3;

- c) for T5 classification, the surface temperature of components with a surface area smaller than 10 cm<sup>2</sup> (excluding lead wires) shall not exceed 150°C.

**Table 3 — Assessment for T4 classification according to component size and ambient temperature**

| Total surface area excluding lead wires                                                 | Requirement for T4 and Group I classification |
|-----------------------------------------------------------------------------------------|-----------------------------------------------|
| < 20 mm <sup>2</sup>                                                                    | Surface temperature ≤ 275°C                   |
| ≥ 20 mm <sup>2</sup>                                                                    | Power dissipation ≤ 1.3 W*                    |
| ≥ 20 mm <sup>2</sup> < 10 cm <sup>2</sup>                                               | Surface temperature ≤ 200°C                   |
| * Reduced to 1.2 W with 60°C ambient temperature or 1.0 W with 80°C ambient temperature |                                               |

For potentiometers, the surface to be considered shall be that of the resistance element and not the external surface of the component. The mounting arrangement and heatsinking and cooling effect of the overall potentiometer construction shall be taken into consideration during the test. Temperature shall be measured on the track with that current that flows under conditions of 'ib' or 'ia' as appropriate. If this results in a resistance value of less than 10% of the track resistance value, the measurement shall be carried out at 10% of the track resistance value.

### 6.2.5 Fusion-sealed components

If components (other than those complying with 6.2.4 and incandescent lamps) have envelopes sealed by fusion, and the envelope or surrounding enclosure can withstand the impact test in 23.4.3.1 of ANSI/ISA-60079-0 without the seal being broken, the relevant temperature is the maximum surface temperature measured on the envelope.

NOTE This requirement is not intended to apply to components, such as transistors and resistors, for which the temperature is always measured on the outer surface.

## 6.3 Facilities for connection of external circuits

### 6.3.1 Terminals

In addition to satisfying the requirements of Table 4, 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 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.

- when separation is accomplished by distance, the clearance between terminals shall be at least 50 mm. Care shall 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;
- 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 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 10.10.2 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 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 10.10.2 if of lesser thickness.

The clearances between bare conducting parts of terminals of separate intrinsically safe circuits shall be equal to or exceed the values given in Table 4. In addition, the clearances between terminals shall be such that the clearances between the bare conducting parts of connected external conductors are at least 6 mm when measured in accordance with Figure 1. Any possible movement of metallic parts that are not rigidly fixed shall be taken into account.

The minimum clearance between the bare conducting parts of external conductors connected to terminals and earthed metal or other conducting parts shall be 3 mm unless the possible interconnection has been taken into account in the safety analysis.

**Table 4 — Clearances, creepage distances and separations**

| 1 | Voltage (peak value)                          | V    | 10  | 30  | 60  | 90  | 190 | 375  | 550  | 750  | 1000 | 1300 | 1575 | 3.3 k | 4.7 k | 9.5 k | 15.6 k |
|---|-----------------------------------------------|------|-----|-----|-----|-----|-----|------|------|------|------|------|------|-------|-------|-------|--------|
| 2 | Clearance                                     | mm   | 1.5 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0  | 7.0  | 8.0  | 10.0 | 14.0 | 16.0 |       |       |       |        |
| 3 | Separation distances through casting compound | mm   | 0.5 | 0.7 | 1.0 | 1.3 | 1.7 | 2.0  | 2.4  | 2.7  | 3.3  | 4.6  | 5.3  | 9.0   | 12.0  | 20.0  | 33.0   |
| 4 | Separation distances through solid insulation | mm   | 0.5 | 0.5 | 0.5 | 0.7 | 0.8 | 1.0  | 1.2  | 1.4  | 1.7  | 2.3  | 2.7  | 4.5   | 6.0   | 10.0  | 16.5   |
| 5 | Creepage distances in air                     | mm   | 1.5 | 2.0 | 3.0 | 4.0 | 8.0 | 10.0 | 15.0 | 18.0 | 25.0 | 36.0 | 49.0 |       |       |       |        |
| 6 | Creepage distance under coating               | mm   | 0.5 | 0.7 | 1.0 | 1.3 | 2.6 | 3.3  | 5.0  | 6.0  | 8.3  | 12.0 | 16.3 |       |       |       |        |
| 7 | Comparative tracking index (CTI)              | 'ia' |     | 100 | 100 | 100 | 175 | 175  | 275  | 275  | 275  | 275  | 275  |       |       |       |        |
|   |                                               | 'ib' |     | 100 | 100 | 100 | 175 | 175  | 175  | 175  | 175  | 175  | 175  |       |       |       |        |

NOTE 1 Except for separation distances, no values for voltages higher than 1575 V are proposed at present.

NOTE 2 At voltages up to 10 V, the CTI of insulating materials is not required to be specified.

### 6.3.2 Plugs and sockets

Plugs and sockets used for connection of external intrinsically safe circuits shall be separate from and non-interchangeable with those for non-intrinsically safe circuits.

Where intrinsically safe or associated apparatus is fitted with more than one plug and socket for external connections, and interchange could adversely affect the type of protection, such plugs and sockets shall either be arranged, for example, by keying, so that interchange is not possible, or mating plugs and sockets shall be identified, for example, by marking or color coding, to make interchanging obvious.

Where a plug or a socket is not prefabricated with its wires, the connecting facilities shall conform to 6.3.1. If, however the connections require the use of a special tool, for example, by crimping, such that there is no possibility of a strand of wire becoming free, then the connection facilities need only conform to Table 4.

Where a connector carries earthed circuits, and the type of protection depends on the earth connection, then the connector shall be constructed in accordance with 6.6.

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

The maximum external inductance to resistance ratio ( $L_o/R_o$ ) that 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  $C_i < C_s$  for the output terminals of the apparatus exceeds 1% of  $C_o$ .

$$\frac{L_o}{R_o} = \frac{8eR_i + (64e^2R_i^2 - 72U_o^2eL_i)^{1/2}}{4.5U_o^2} \quad \text{H}/\Omega \quad \frac{L_o}{R_o} = \frac{8eR_s + (64e^2R_s^2 - 72U_o^2eL_s)^{1/2}}{4.5U_o^2} \quad \text{H}/\Omega$$

where

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

Group I apparatus: 525  $\mu\text{J}$

Group IIA apparatus: 320  $\mu\text{J}$

Group IIB apparatus: 160  $\mu\text{J}$

Group IIC apparatus: 40  $\mu\text{J}$

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

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

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

If  $L_i$   $L_s = 0$

then

$$\frac{L_o}{R_o} = \frac{32 e R_i}{9 U_o^2} \quad \underline{\underline{\frac{H}{\Omega} \frac{L_o}{R_o} = \frac{32 e R_s}{9 U_o^2} \frac{H}{\Omega}}}$$

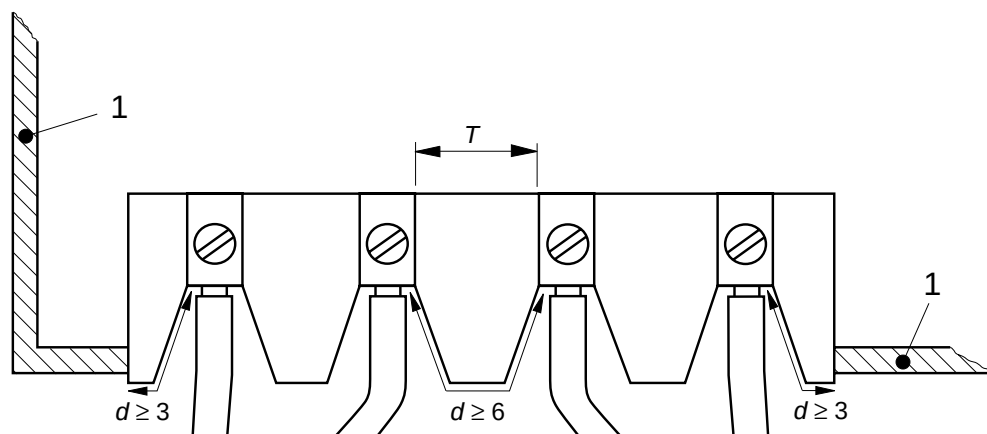
Where a safety factor of 1 is required, this value for  $L_o/R_o$  shall be multiplied by 2.25.

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.

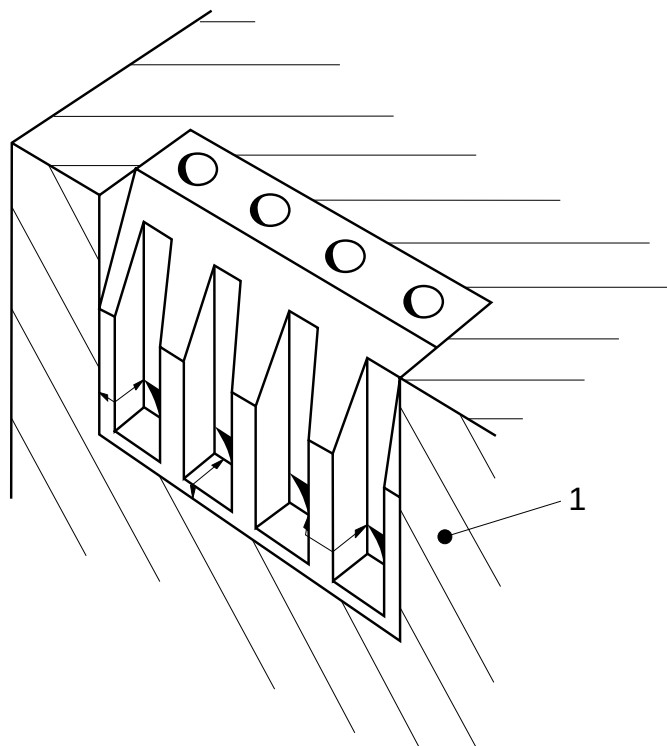
NOTE 2 The above calculation of  $L_o/R_o$  is for power sources with resistive outputs. Non-linear output characteristics require special consideration.

#### 6.3.4 Permanently connected cables

Apparatus constructed with a permanently connected cable shall conform to 10.13.



$T$  clearance and creepage in accordance with table 4  
 $d$  clearance and creepage in accordance with 6.3.1



1. Conductive cover

NOTE Dimensions shown are the creepage and clearance distances around the insulation as indicated above NOT the thickness of the insulation

Dimensions in mm

**Figure 1 – Clearance and creepage distance requirements for terminals carrying separate intrinsically safe circuits**

## 6.4 Separation distances

### 6.4.1 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 this 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.

If the separation conforms to Table 4, it shall be considered as not subject to failure to a lower insulation resistance.

Smaller separation distances, which exceed one-third of the values specified in Table 4, shall be considered as subject to countable short-circuit faults.

If separation distances are less than one-third of the values specified in Table 4, they shall be considered as subject to non-countable, short-circuit faults if this impairs intrinsic safety.

Separation requirements shall not apply where earthed metal, for example, printed wiring 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 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 10.10.2 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 0.9mm, or shall conform to 10.10.2 if of lesser thickness.

NOTE Methods of assessment are given in Annex C.

### 6.4.2 Voltage between conductive parts

The voltage that is taken into account when using Table 4 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 3), 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 that are galvanically separated within the apparatus, the value of voltage to be considered between the circuits shall be the highest voltage which 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 that 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:

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

- 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 that 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.

#### 6.4.3 Clearance

In measuring or assessing clearances between conductive parts, insulating partitions of less than 0.9 mm thickness, or that do not conform to 10.10.2, shall be ignored. Other insulating parts shall conform to line 4 of Table 4.

For voltages higher than 1575 V peak, an interposing insulating partition or earthed-metal partition shall be used. In either case, the partition shall conform to 6.4.

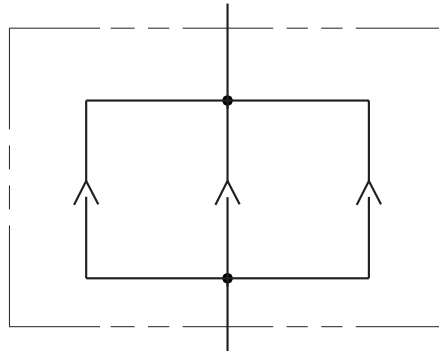


**Figure 2a — Example of three independent connecting elements**

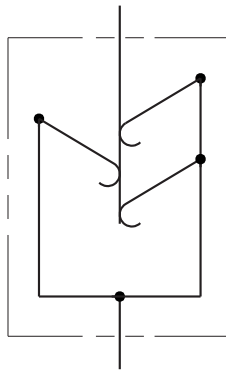


**Figure 2b — Example of three connecting elements that are not independent**

## **Figure 2 — Examples of independent and non-independent connecting elements**

### 6.4.4 Separation distances through and requirements of casting compound

The casting compound shall conform to the following:

- a) It shall have a temperature rating, specified by the manufacturer of the casting compound or apparatus, that is at least equal to the maximum temperature achieved by any component under encapsulated conditions.

Alternatively higher temperatures than the rated casting compound temperature shall be accepted provided that they do not cause any damage to the casting compound that would adversely affect this type of protection.

- b) It shall have at its free surface a CTI value of at least that specified in Table 4 if any bare conductive parts protrude from the casting compound.

Only hard material, for example, epoxy resin, shall have its free surface exposed and unprotected, thus forming part of the enclosure (see Figure D.1). It shall conform to 10.10.1.

- c) be adherent to all conductive parts, components and substrates except when they are totally enclosed by the casting compound.
- d) be specified by its generic name and type designation given by the manufacturer of the casting compound.

For intrinsically safe apparatus, all circuits connected to the encapsulated conductive parts and/or components and/or bare parts protruding from the casting compound shall be intrinsically safe. Fault conditions within the casting compound shall be assessed, but the possibility of spark ignition shall not be considered.

If circuits connected to the encapsulated conductive parts and/or components and/or bare parts protruding from the casting compound are not intrinsically safe, they shall be protected by another type of protection listed in ANSI/ISA-60079-0 IEC 60079-0.

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 line 3 of Table 4 with a minimum separation distance of 1 mm. When the casting compound is in direct contact with an enclosure of insulating material conforming to line 4 of Table 4, no other separation is required (see Figure D.1).

The insulation of the encapsulated circuit shall conform to 6.4.12.

The failure of a component that is encapsulated or hermetically sealed, e.g., 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.

Further requirements are given in Annex D.

#### 6.4.5 Separation distances through solid insulation

Solid insulation is insulation that is extruded or moulded but not poured. It shall have an electrical strength that conforms to 6.4.12 when the separation distance is in accordance with Table 4.

NOTE 1 If the insulator is fabricated from two or more pieces of electrical insulating material that 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.

#### 6.4.6 Composite separations

Where separations 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 line of Table 4. For example at 60 V:

clearance (line 2) = 6 x separation through solid insulation (line 4);

clearance (line 2) = 3 x separation through casting compound (line 3);

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

To be infallible the above result shall be not less than the clearance value specified in Table 4.

Any clearance or separation which is below one-third of the relevant value specified in Table 4 shall be ignored for the purpose of calculation.

#### 6.4.7 Creepage distance in air

For the creepage distance in air specified in line 5 of Table 4, the insulating material shall conform to line 7 of Table 4 which specifies the minimum comparative tracking index (CTI) measured in accordance with IEC 60112. The method of measuring or assessing these distances shall be in accordance with Figure 4.

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 line 5 of Table 4 shall not be taken into account.

For voltages higher than 1575 V peak, an interposing insulating partition or earthed metallic partition shall be used. In either case the partition shall conform to 6.4.1.

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