

Electrical apparatus for potentially explosive atmospheres — Intrinsic safety ‘i’

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British Standard

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Cooperating organizations

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National foreword

This British Standard has been prepared under the direction of the General Electrotechnical Standards Policy Committee and is the English language version of EN 50020 : 1993 *Electrical apparatus for potentially explosive atmospheres — Intrinsic safety 'i'*, second edition including corrigendum : 1998, published by the European Committee for Electrotechnical Standardization (CENELEC).

The standard should be read in conjunction with BS EN 50014 : 1993 *Electrical apparatus for potentially explosive atmospheres — General requirements* which it supplements.

Textual errors. When implementing the English language version of EN 50020 as the national standard, the textual errors listed below were discovered. They have been reported to CENELEC in a proposal to amend the text of the European standard.

In table 4, the value for the creepage distance under coating at a voltage of 1575 V should read '16,3' rather than '13,3'.

In C.1, in the paragraph above the first table, 'line 5 of table 4' should read 'line 2 of table 4'. In the paragraph above the second table, 'line 6 of table 4' should read 'line 3 of table 4'. In the paragraph above the third table, 'line 7 of table 4' should read 'line 4 of table 4'.

Product certification. Users of this British Standard are advised to consider the desirability of third party certification of product conformity with this British Standard based on testing and continuing product surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

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English version

Electrical apparatus for potentially explosive atmospheres — Intrinsic safety 'i'

Matériel électrique pour atmosphères explosibles
Sécurité intrinsèque 'i'

Elektrische Betriebsmittel für explosionsgefährdete
Bereiche Eigensicherheit 'i'

This European Standard was approved by CENELEC on 1993-03-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

This European Standard was prepared by CENELEC Subcommittee SC 31-3, Intrinsically safe apparatus and systems 'I'.

It was submitted to the CENELEC Unique Acceptance Procedure (UAP) in June 1992 and was approved by CENELEC as EN 50020 on 1993-03-09. This European Standard supersedes EN 50020 : 1977 and its amendments A1 : 1979 to A5 : 1990.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-01-15
- latest date of withdrawal of conflicting national standards (dow) —

This European Standard is to be read in conjunction with EN 50014 : 1992, *Electrical apparatus for potentially explosive atmospheres — General requirements*, and with the second editions of the European Standards for the specific types of protection listed in the scope of EN 50014 : 1992. This European Standard should not be considered in conjunction with any of the first edition standards and their amendments, published in 1977 or thereafter, listed in EN 50014 : 1977.

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1 Scope

1.1 This European Standard 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.

1.2 This European Standard supplements EN 50014 : 1992 *Electrical apparatus for potentially explosive atmospheres — general requirements* edition 1992, 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 EN 50014 then the requirements of that method of protection together with the relevant Parts of EN 50014 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 hazardous atmosphere and in other circumstances should be used in combination with the requirements of the other methods of protection.

Clause of EN 50014 : 1992		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	Requirements 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
7.3.1	Electrical apparatus of Group I (Notes 1 and 2 only)	Yes	Yes
7.3.2	Electrical apparatus of Group II (Notes 1 and 2 only)	Yes	Yes
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
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 23.4.7.7	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
Annex E	Methods of measurement of the insulation resistance of parts of enclosures of plastics materials	No	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 atmosphere.

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 EN 50014, 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.

NOTE. Methods of interconnection of intrinsically safe apparatus and associated apparatus are specified in EN 50039.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

European Standards

EN 50014 : 1992	<i>Electrical apparatus for potentially explosive atmospheres. General requirements.</i>
EN 50019	<i>Electrical apparatus for potentially explosive atmospheres. Increased safety 'e'.</i>
EN 50039	<i>Electrical apparatus for potentially explosive atmospheres. Intrinsically safe electrical systems 'i'.</i>

International publications with references to the corresponding European publications

IEC publications		EN/HD
IEC 85 : 1984	<i>Thermal evaluation and classification of electrical insulation</i>	HD 566 S1
IEC 112 : 1979	<i>Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions</i>	HD 214 S2
IEC 127-1 : 1988 + corrigendum 1990	<i>Miniature fuses</i> Part 1: <i>Definitions for miniature fuses and general requirements for miniature fuse-links</i>	EN 60127-1
IEC 127-2 : 1989 + corrigendum 1990	<i>Miniature fuses</i> Part 2: <i>Cartridge fuse-links</i>	EN 60127-2
IEC 127-3 : 1988	<i>Miniature fuses</i> Part 3: <i>Sub-miniature fuse-links</i>	EN 60127-3
IEC 529 : 1989	<i>Classification of degrees of protection provided by enclosures</i>	EN 60529

3 Definitions

For the purposes of this standard the following definitions apply; they supplement the definitions which are given in EN 50014.

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 EN 50014.

3.3 intrinsically safe apparatus

Electrical apparatus in which all the circuits are intrinsically safe circuits.

3.4 associated apparatus

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.

NOTE. Associated apparatus may be either:

- a) electrical apparatus which has an alternative type of protection listed in EN 50014 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.

3.7 countable fault

Fault which occurs in parts of electrical apparatus conforming to the constructional requirements of this standard.

3.8 non-countable fault

Fault which occurs in parts of electrical apparatus not conforming to the constructional requirements of this standard.

3.9 infallible component or infallible assembly of components

Component or assembly that is not likely to become defective, in service or in storage, in such a manner as to invalidate intrinsic safety.

3.10 infallible separation or insulation

Separation or insulation between electrically conductive parts that is not considered as becoming short circuited in service or storage and therefore will not be considered to fail for the purposes of fault analysis and the application of the spark test apparatus.

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.

3.12 internal wiring

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

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.

3.16 maximum input voltage (U_i)

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)

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 .

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)

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)

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)

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

3.23 maximum internal capacitance (C_i)

Total equivalent internal capacitance of the apparatus which is considered as appearing across the connection facilities of the apparatus.

3.24 maximum external inductance (L_o)

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

3.25 maximum internal inductance (L_i)

Total equivalent internal inductance of the 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)

Ratio of inductance (L_o) to resistance (R_o) of any external circuit that can be connected to the connection facilities of the 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 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 which 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.

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 EN 60127 or to its manufacturer's specification.

3.34 sealed gas tight cell or battery

A cell or battery which 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 which is closed under normal conditions but which has an arrangement which 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.

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 EN 50014 : 1992.

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 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.

NOTE. 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 to voltage or current or a combination of these 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.

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.

NOTE. 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 to voltage or current or a combination of these 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.

5.4 Simple apparatus

The following apparatus shall be considered to be simple apparatus:

- a) passive components, e.g. switches, junction boxes, potentiometer and simple semiconductor devices.
- b) sources of stored energy with well defined parameters, e.g. capacitors or inductors, whose values shall be considered when determining the overall safety of the system.
- c) sources of generated energy, e.g. 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 certified and need not comply with clause **12**. In particular 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, e.g. circuits for the generation of ancillary power supplies.
- 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 **6.4.12**. Its terminals shall conform to **6.3.1**.
- 4) Non metallic enclosures and enclosures containing light metals when located in the hazardous area shall conform to **7.3** and **8.1** of EN 50014.
- 5) When simple apparatus is located in the hazardous area it shall be temperature classified. When used in an intrinsically safe circuit within their normal rating 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.

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 EN 50014, except for those excluded by 1.2.

For example, the requirements for encapsulation with casting compound apply only if encapsulation 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 protection is embodied within the circuits themselves. 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 IP20 in accordance with EN 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 IP54 in accordance with EN 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 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).

6.2 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 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.

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

where:

- α is the temperature coefficient of resistance of the wire material (0,004265 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 amps;
- T is the temperature at which the wire melts, in degrees Celsius (1083 °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

Diameter (see note 4)	Cross-sectional area (see note 4)	Maximum permissible current for temperature classification		
		T1-T4 and Group I	T5	T6
mm	mm ²	A	A	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 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 area are the nominal dimensions specified by the wire manufacturer.
NOTE 5. Where 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 35 μm 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 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

Minimum track width mm	Maximum permissible current for temperature classification		
	T1 to T4 and Group I A	T5 A	T6 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 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 35µm thickness.
 NOTE 3. For boards with thicknesses 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 18µm copper thickness, divide the maximum current specified by 1,5.
 NOTE 7. For 70µm 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, e.g. transistors or resistors, whose temperature exceeds that permitted for the temperature classification shall be acceptable providing that they conform to one of the following.

- a) When tested in accordance with 10.7, small components shall not cause ignition of the flammable mixture and any deformation or

deterioration by the higher temperature shall not impair the type of protection.

b) 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 cm² (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 ²	Surface temperature ≤ 275 °C
≥ 20 mm ²	Power dissipation ≤ 1,3 W*
≥ 20 mm ² < 10 cm ²	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 which 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.

6.3 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.

a) When separation is accomplished by distance then 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.

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 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 which 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.

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, e.g. by keying, so that interchange is not possible or mating plugs and sockets shall be identified, e.g. by marking or colour 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, e.g. 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.

If a connector carries earthed circuits and this type of protection depends on the earthed 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) 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_i for the output terminals of the apparatus exceeds 1 % of C_o .

$$\frac{L_o}{R_o} = \frac{8eR_i + (64e^2R_i^2 - 72U_o^2 e L_i)^{1/2}}{4,5 U_o^2} \quad (\text{H}/\Omega) \quad |$$

where

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

Group I apparatus:	525 μJ
Group IIA apparatus:	320 μJ
Group IIB apparatus:	160 μJ
Group IIC apparatus:	40 μJ

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

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

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

If $L_i = 0$ |

then

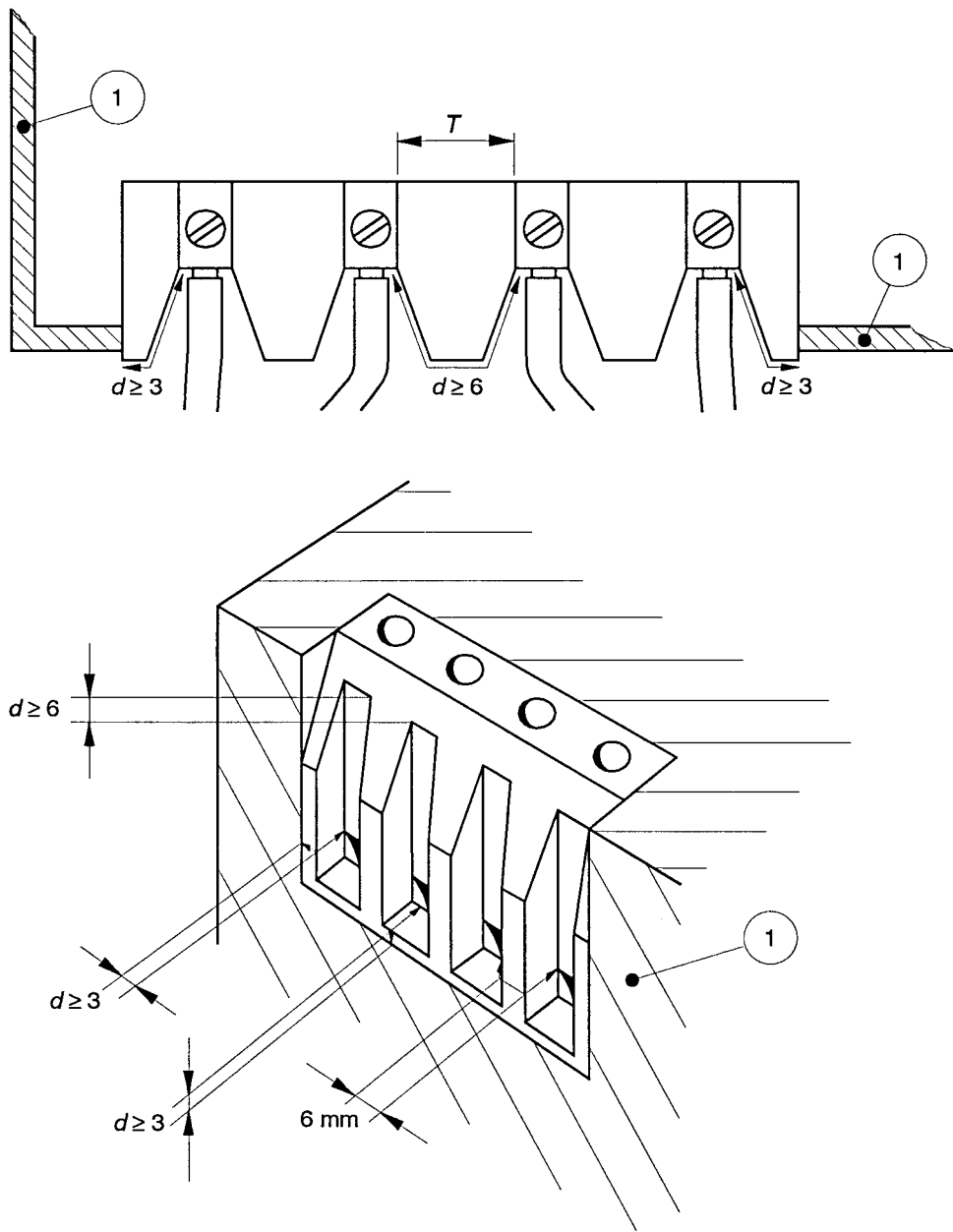
$$\frac{L_o}{R_o} = \frac{32 e R_i}{9 U_o^2} \quad (\text{H}/\Omega) \quad |$$

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, e.g. cables. Its use for lumped values of inductance and resistance requires special consideration.

NOTE 2. The calculations of L_o/R_o for power sources with non-linear output characteristics requires special consideration.

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	3	4	5	6	7	8	10	14	16				
3	Separation distances through casting compound		mm	0,5	0,7	1	1,3	1,7	2	2,4	2,7	3,3	4,6	5,3	9	12	20	33
4	Separation distances through solid insulation		mm	0,5	0,5	0,5	0,7	0,8	1	1,2	1,4	1,7	2,3	2,7	4,5	6	10	16,5
5	Creepage distances in air		mm	1,5	2	3	4	8	10	15	18	25	36	49				
6	Creepage distance under coating		mm	0,5	0,7	1	1,3	2,6	3,3	5	6	8,3	12	13,3				
7	Comparative tracking index	ia	CTI	100				100	100	175	175	275	275	275	275			
		ib	CTI	100				100	100	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.																		



1 Conductive cover
T Clearance and creepage distance in accordance with table 4
d Clearance and creepage distance in accordance with 6.3.1

Dimensions in millimetres.

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

6.3.4 Permanently connected cables

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

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 account of 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.

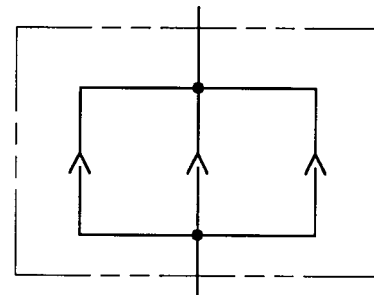
Separation requirements shall not apply where earthed metal, e.g. printed wiring or a partition, separates an intrinsically safe circuit from other circuits, provided that breakdown to earth does not adversely affect the type of protection and that the earthed conductive part can carry the maximum current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

NOTE 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.

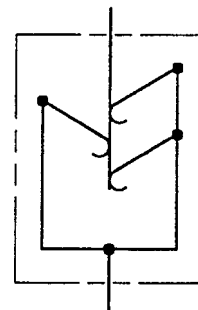
An earthed metal partition shall have strength and rigidity so that it is unlikely to be damaged and shall be of sufficient thickness and of sufficient current-carrying capacity to prevent burn-through or loss of earth under fault conditions. A partition either shall be at least 0,45 mm thick and attached to a rigid, earthed metal portion of the device or shall conform to 10.10.2 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 0,9 mm or shall conform to 10.10.2 if of lesser thickness.

NOTE 2. Methods of assessment are given annex C.



a) Example of three completely independent connecting elements



b) Example of three connecting elements which are not independent

Figure 2. Examples of independent and non-independent connecting elements

6.4.2 Voltage between conductive parts

The voltage which 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 separate circuits: the highest numerical sum of the peak voltages 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:

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

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, e.g. 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 which 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.

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, which 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) 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, e.g. 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.

NOTE. If circuits connected to the encapsulated conductive parts and/or components and/or bare parts protruding the casting compound are not intrinsically safe, they shall be protected by some other appropriate technique, listed in EN 50014.

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 which 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 which is extruded or moulded but not poured. It shall have an electrical strength which 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 which are solidly bonded together, then the composite may be considered as solid.

NOTE 2. For the purposes of this standard, solid insulation is considered to be prefabricated, e.g. sheet or sleeving or elastomeric insulation on wiring.

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

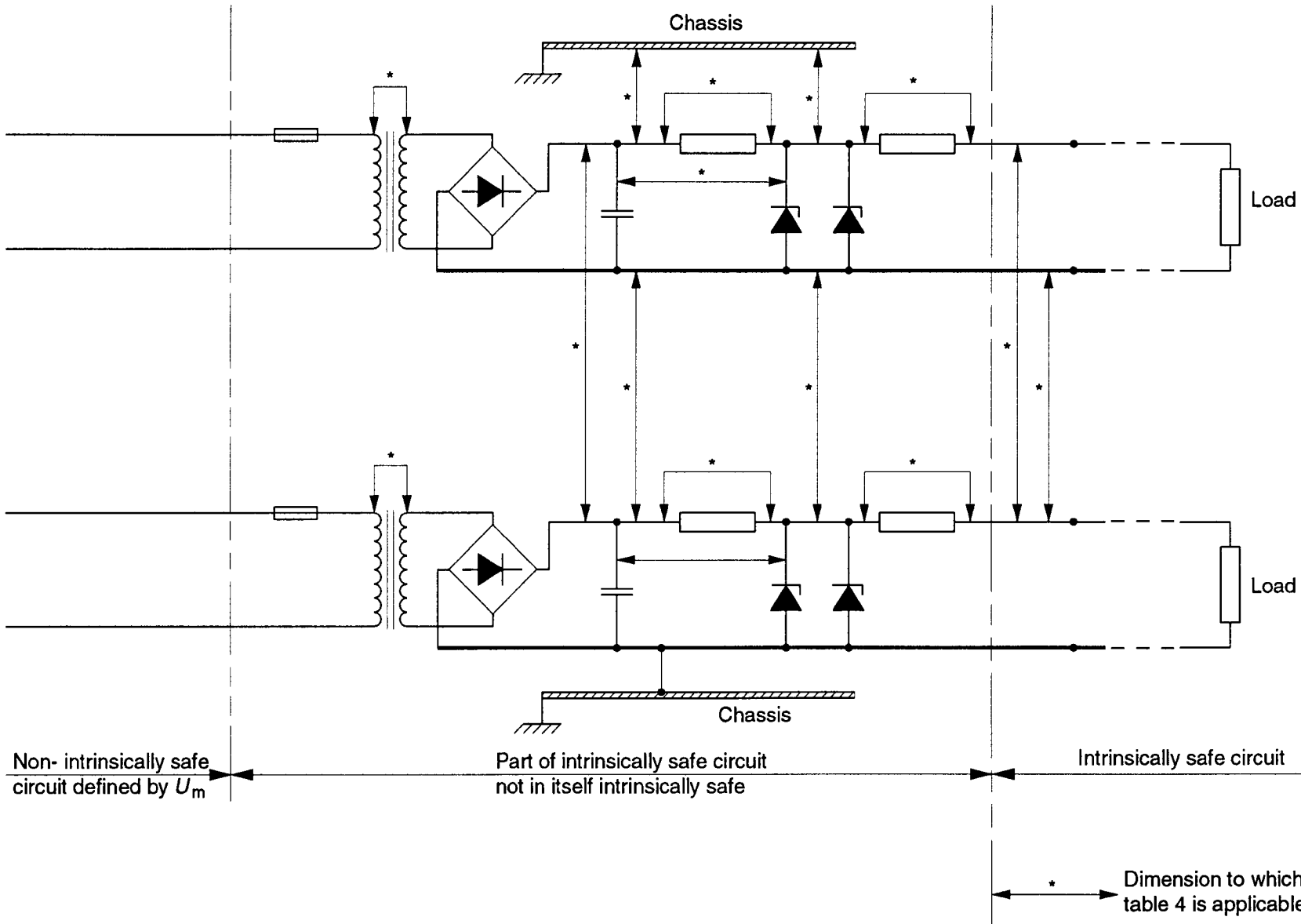


Figure 3. Separation of conducting parts

6.4.6 Composite separations

Where separations are composite, e.g. 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) = $6 \times$ separation through solid insulation (line 4);

Clearance (line 2) = $3 \times$ separation through casting compound (line 3);

Equivalent clearance = actual clearance + ($3 \times$ any additional separation through encapsulant) + ($6 \times$ 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 112. The method of measuring or assessing these distances shall be in accordance with figure 4.

Where a joint is cemented then 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, e.g. 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.

6.4.8 Creepage distance under coating

A conformal coating shall seal the conductors in question against ingress of moisture and shall give an effective lasting unbroken seal. It shall adhere to the conductive parts and to the insulating material. If the coating is applied by spraying, two separate coats shall be applied. Other methods of application require only one coat, for example: dip coating, brushing, vacuum impregnating. A solder mask shall be considered as one of the two coatings, provided it is not damaged during soldering.

Where bare conductors emerge from the coating the comparative tracking index (CTI) in line 7 of table 4 shall apply to both insulation and coating.

NOTE. The concept of creepage distances under coating was developed for flat surfaces, e.g. non-flexible printed circuit boards. Radical departures from this format require special consideration.

6.4.9 Requirements for assembled printed circuit boards

Where creepage and clearance distances affect the intrinsic safety of the apparatus the printed circuit shall conform to the following (see figure 5).

a) When a printed circuit is covered by a conformal coating according to 6.4.8, the requirements of 6.4.3 and 6.4.7 shall apply only to any conductive parts which lie outside the coating, including, for example:

- tracks which emerge from the coating;
- the free surface of a printed circuit which is coated on one side only;
- bare parts of components able to protrude through the coating.

b) The requirements of 6.4.8 shall apply to circuits or parts of circuits and their fixed components when the coating covers the connecting pins, solder joints and the conductive parts of any components.

6.4.10 Separation by earth screens

Where separation between circuits or parts of circuits is provided by a metallic screen, the screen, as well as any connection to it, shall be capable of carrying the maximum possible current to which it could be continuously subjected in accordance with clause 5.

Where the connection is made through a connector, the connector shall be constructed in accordance with 6.6.

6.4.11 Internal wiring

Insulation, except for varnish and similar coatings, covering the conductors of internal wiring shall be considered as solid insulation (see 6.4.5).

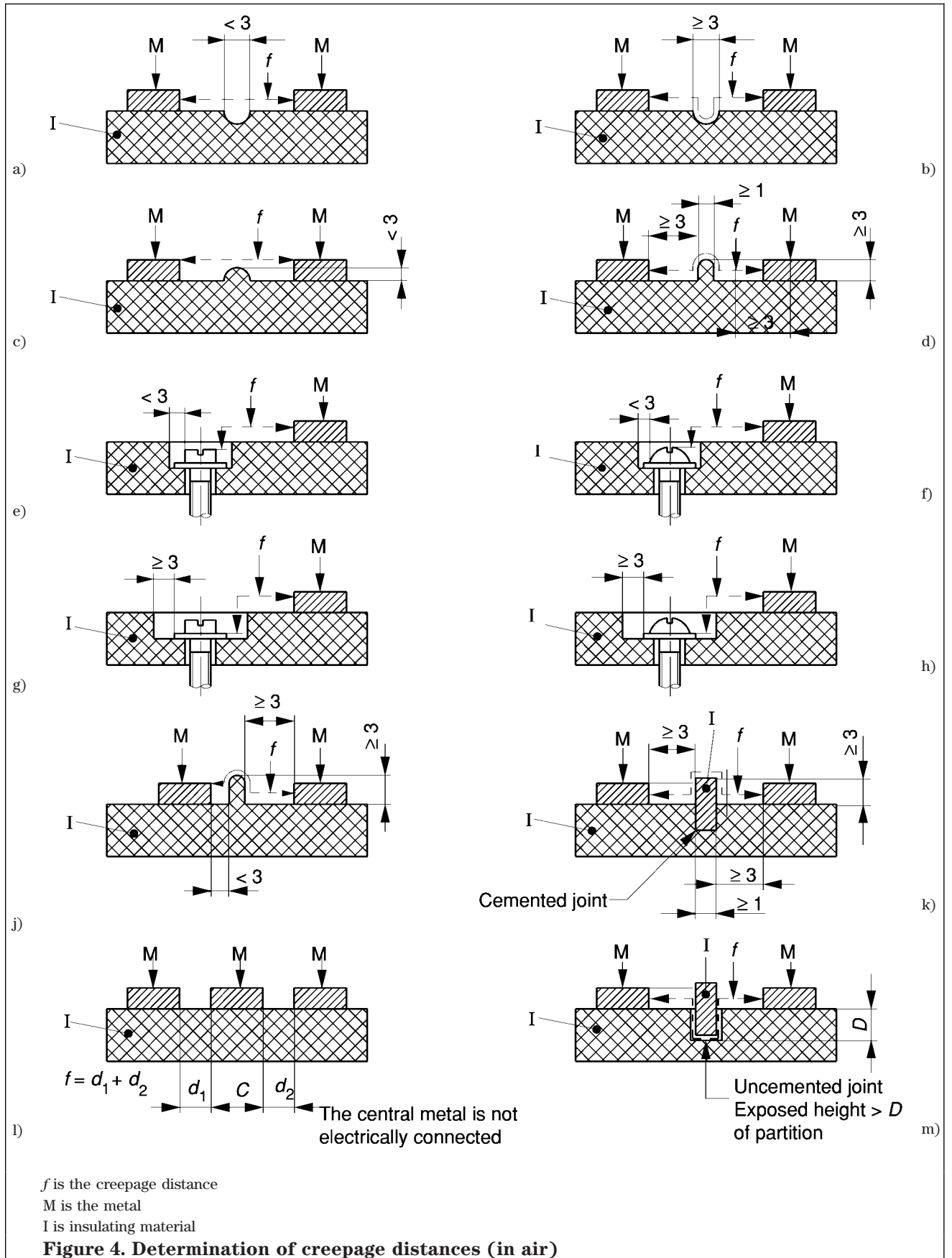
The separation of conductors shall be determined by adding together the radial thicknesses of extruded insulation on wires which are lying side by side either as separate wires or in a cable form or in a cable.

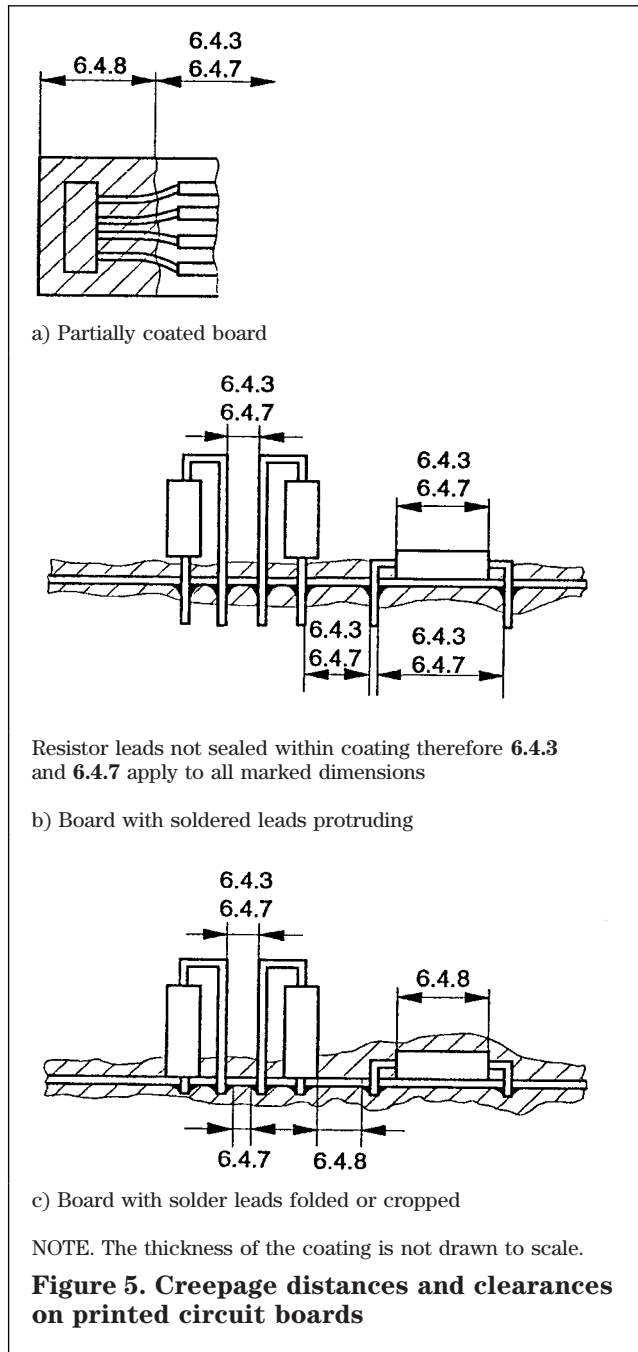
The distance between the conductors of any core of an intrinsically safe circuit and that of any core of a non-intrinsically safe circuit shall be in accordance with line 4 of table 4 taking account of the requirements of 6.4.6 except when one of the following apply:

the cores of either the intrinsically safe or the non-intrinsically safe circuit are enclosed in an earthed screen;

or, in category 'ib' electrical apparatus, the insulation of the intrinsically safe cores is capable of withstanding an r.m.s. a.c. test voltage of 2000 V.

NOTE. One method of achieving insulation capable of withstanding this test voltage is to add an insulating sleeve over the core.





6.4.12 Electric strength tests

The insulation between an intrinsically safe circuit and the frame of the electrical apparatus or parts which may be earthed shall normally be capable of withstanding an r.m.s. a.c. test voltage of twice the voltage of the intrinsically safe circuit or 500 V whichever is the greater.

Either the current flowing during the test shall not increase above that which is expected from the design of the circuit and shall not exceed 5 mA r.m.s. at any

time, or where the circuit does not satisfy this requirement the apparatus shall be marked with the symbol X.

The insulation between an intrinsically safe circuit and a non-intrinsically safe circuit shall be capable of withstanding an r.m.s. a.c. test voltage of $2U + 1000$ V with a minimum of 1500 V r.m.s. where U is the sum of the r.m.s. values of the voltages of the intrinsically safe circuit and the non-intrinsically safe circuit.

Where breakdown between separate intrinsically safe circuits could produce an unsafe condition, the insulation between these circuits shall be capable of withstanding an r.m.s. test voltage of $2U$ with a minimum of 500 V, where U is the sum of the r.m.s. values of the voltages of the circuits under consideration.

The test method used in the above tests shall be in accordance with 10.6.

6.4.13 Relays

Where the coil of a relay is connected to an intrinsically safe circuit, the contacts in normal operation shall not exceed their manufacturer's rating and shall not switch more than 5 A r.m.s. or 250 V r.m.s. or 100 V·A. When the values switched by the contacts do not exceed 10 A or 500 V·A, the values for creepage distance and clearance from table 4 for the relevant voltage shall be doubled.

For higher values, intrinsically safe circuits and non-intrinsically safe circuits shall be connected to the same relay only if they are separated by an earthed metal barrier or an insulating barrier conforming to 6.4.1. The dimensions of such an insulating barrier shall take into account the ionization arising from operation of the relay which would generally require creepage distances and clearances greater than those given in table 4.

Where a relay has contacts in intrinsically safe circuits and other contacts in non-intrinsically safe circuits the intrinsically safe and non-intrinsically safe contacts shall be separated by an insulating or earthed metal barrier conforming to 6.4.1 in addition to table 4. The relay shall be designed such that broken or damaged contact arrangements cannot become dislodged and impair the integrity of the separation between intrinsically safe and non-intrinsically safe circuits.

6.5 Protection against polarity reversal

Protection shall be provided within intrinsically safe apparatus to prevent invalidation of the type of protection as a result of reversal of the polarity of supplies to that apparatus or at connections between cells of a battery where this could occur. For this purpose a single diode shall be acceptable.

6.6 Earth conductors, connections and terminals

Where earthing, e.g. of enclosures, conductors, metal screens, printed wiring board conductors, segregation contacts of plug-in connectors and diode safety barriers, is required to maintain the type of protection, the cross-sectional area of any conductors, connectors and terminals used for this purpose shall be such that they are rated to carry the maximum possible current to which they could be continuously subjected under the conditions specified in clause 5. Components shall also conform to clause 7.

Where a connector carries earthed circuits and the type of protection depends on the earthed circuit, the connector shall comprise at least three independent connecting elements for 'ia' circuits and at least two for 'ib' circuits (see figure 2). These elements shall be connected in parallel. Where the connector can be removed at an angle one connection shall be present at, or near to, each end of the connector.

Terminals shall be fixed in their mountings without possibility of self-loosening; and shall be constructed so that the conductors cannot slip out from their intended location. Proper contact shall be assured without deterioration of the conductors, even if multi-stranded cores are used in terminals which are intended for direct clamping of the cores. The contact made by a terminal shall not be appreciably impaired by temperature changes in normal service. Terminals which are intended for clamping stranded cores shall include a resilient intermediate part. Terminals for conductors of cross sections up to 4 mm² shall also be suitable for the effective connection of conductors having a smaller cross section. Terminals which comply with the requirements of EN 50019 are considered to conform to these requirements.

The following shall not be used:

- a) terminals with sharp edges which could damage the conductors;
- b) terminals which may turn, be twisted or permanently deformed by normal tightening;
- c) insulating materials which transmit contact pressure in terminals.

6.7 Encapsulation used for exclusion of potentially explosive atmosphere

Where casting compound is used to exclude a potentially explosive atmosphere from components and intrinsically safe circuits, e.g. fuses, piezo-electric devices with their suppression components and energy storage devices with their suppression components, it shall conform to 6.4.4.

In addition, where casting compound is used to reduce the ignition capability of hot components, e.g. diodes and resistors, the volume and thickness

of the casting compound shall reduce the maximum surface temperature of the casting compound to the desired value.

7 Components on which intrinsic safety depends

7.1 Rating of components

In both normal operation and after application of the fault conditions given in clause 5 any remaining components on which the type of protection depends, except such devices as transformers, fuses, thermal trips, relays and switches, shall not operate at more than two-thirds of their maximum current, voltage and power related to the rating of the device, the mounting conditions and the temperature range specified. These maximum rated values shall be the normal commercial ratings specified by the manufacturer of the component.

Detailed testing or analysis of components and assemblies of components to determine the parameters, e.g. voltage and current, to which the safety factors are applied shall not be performed, since the factors of safety of 5.2 and 5.3 obviate the need for detailed testing or analysis. For example a zener diode stated by its manufacturer to be 10 V + 10 % at 40 °C shall be taken to be 11 V maximum without the need to take into account effects such as voltage elevation due to rise in temperature.

Account shall also be taken of the effects of the mounting conditions and ambient temperature range specified by the manufacturer of the apparatus and by 5.2 of EN 50014 : 1992. For example, in the case of a semiconductor the power dissipation shall not exceed two-thirds of that which will cause the maximum junction temperature to be reached under the particular mounting conditions.

7.2 Connectors for internal connections, plug-in cards and components

These connectors shall be designed in such a manner that an incorrect connection or interchangeability with other connectors in the same electrical apparatus is not possible unless it does not result in an unsafe condition or the connectors are identified in such a manner that incorrect connection is obvious.

Where the type of protection depends on a connection, the failure to a high resistance or open circuit of a connection shall be a countable fault in accordance with clause 5.

If 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.

7.3 Fuses

Where fuses are used to protect other components, $1,7I_n$ shall be assumed to flow continuously. The fuse time-current characteristics shall ensure that the transient ratings of protected components are not exceeded. Where the fuse time-current characteristic is not available from the manufacturer's data, a type test shall be carried out in accordance with 10.12 on at least ten samples. This test shows the capability of the sample to withstand 1,5 times any transient which can occur when U_m is applied through a fuse.

Fuses located in the hazardous area shall be protected in accordance with 6.7.

Where fuses are encapsulated, the casting compound shall not enter the fuse interior. This requirement shall be satisfied by testing samples or by a declaration from the fuse manufacturer confirming acceptability of the fuse for encapsulation. Alternatively the fuse shall be sealed prior to encapsulation.

Fuses used to protect components shall be replaceable only by opening the apparatus enclosure. The type designation and I_n , or the characteristics important to intrinsic safety shall be marked adjacent to the fuses.

Fuses shall have a rated voltage of at least U_m (or U_i in intrinsically safe apparatus and circuits) although they do not have to conform to table 4. General industrial standards for the construction of fuses and fuseholders shall be applied and their method of mounting shall not reduce the clearances, creepage distances and separations afforded by the fuse and its holder.

NOTE 1. Microfuses conforming to IEC 127 are acceptable.

A fuse shall be capable of interrupting the maximum prospective current of the circuit in which it is installed. For mains electricity supply systems not exceeding 250 V a.c. the prospective current shall normally be considered to be 1500 A a.c. The breaking capacity of the fuse is determined according to IEC 127 or an equivalent standard.

NOTE 2. Higher prospective currents may be present in some installations, e.g. at higher voltages.

If a current limiting device is necessary to limit the prospective current to a value not greater than the rated breaking capacity of the fuse, this device shall be infallible in accordance with clause 7 and the rated values shall be at least:

current rating $1,5 \times 1,7 \times I_n$;

voltage rating U_m or U_i ;

power rating $1,5 \times (1,7 \times I_n)^2 \times$ resistance of limiting device.

7.4 Primary and secondary cells and batteries

7.4.1 General

Some types of cells and batteries, e.g. some lithium types, may explode if short-circuited or subjected to reverse charging. Where such an explosion could adversely affect intrinsic safety the use of such cells and batteries must be confirmed by their manufacturer as being safe for use in any particular intrinsically safe or associated apparatus when 5.2 or 5.3 as appropriate is applied. The documentation, and if practicable the marking, for the apparatus shall draw attention to the safety precautions to be observed.

NOTE. Attention is drawn to the fact that the cell or battery manufacturer often specifies precautions for the safety of personnel.

7.4.2 Electrolyte leakage

Either cells and batteries shall be of a type from which there can be no spillage of electrolyte or they shall be enclosed to prevent damage by the electrolyte to the components upon which safety depends. Cells and batteries declared as sealed (gas tight) or sealed (valve regulated) by their manufacturer (see 7.4.9) shall be deemed to satisfy this requirement. Other cells and batteries shall be tested in accordance with 10.9.2 or written confirmation shall be obtained from the cell/battery manufacturer that the product conforms to 10.9.2. If cells and batteries which leak electrolyte are encapsulated in accordance with 6.7, they shall be tested in accordance with 10.9.2 after encapsulation.

Compartments containing cells or batteries which are charged within them shall be ventilated directly to the outside of the equipment.

7.4.3 Cell and battery voltages

For the purpose of evaluation and test, the cell/battery voltage shall be considered to be the maximum open circuit voltage attainable from either a new primary cell/battery or a secondary cell/battery just after a full charge as specified in table 5. When the cell or battery is not covered by table 5 it shall be tested in accordance with 10.9 to determine the maximum open circuit voltage and the nominal voltage shall be that specified by the cell or battery manufacturer.

7.4.4 Internal resistance of battery and cell

The internal resistance of a battery or cell shall be determined in accordance with 10.9.3.

7.4.5 Current limiting devices for batteries in associated apparatus

The battery housing or means of attachment of associated apparatus shall be constructed so that the battery can be installed and replaced without adversely affecting the intrinsic safety of the apparatus.

NOTE. Where a current limiting device is necessary to ensure the safety of the battery output, there is no requirement for the current limiting device to be an integral part of the battery.