

Electrical apparatus for potentially explosive atmospheres —

Part 7: Intrinsic safety “i”

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Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the National Committees of the following countries.

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Summary of pages

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This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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explosibles — Sécurité intrinsèque “i”
*(inclut les amendements A2:1985 + A3:1990 +
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Elektrische Betriebsmittel für
explosionsgefährdete Bereiche —
Eigensicherheit “i”
*(enthält Änderungen A2:1985 + A3:1990 +
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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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IEC Publications referred to in European Standard EN 50020

IEC 85:1957 (1st edition)	<i>Recommendations for the classification of materials for the insulation of electrical machinery and apparatus in relation to their thermal stability in service</i>
IEC 112:1971 (2nd edition)	<i>Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions</i>
IEC 144:1963 (1st edition)	<i>Degrees of protection of enclosures for low-voltage switchgear and controlgear</i>
IEC 249-1:1982	<i>Base materials for printed circuits (Test methods) (HD 313)</i>
IEC 348:1971 (1st edition)	<i>Safety requirements for electronic measuring apparatus</i>
IEC 587:1977	<i>Test method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions (HD 380)</i>

ISO Standard referred to in European Standard EN 50020

ISO/R 54:1966	<i>Modules and diametral pitches of cylindrical gears for general engineering and for heavy engineering</i>
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European Standards referred to in European Standard EN 50020

EN 50014 (March 1977) (Edition 1)	<i>Electrical apparatus for potentially explosive atmospheres: General requirements</i> With: Amendment 1 of July 1979 Amendment 2 of June 1982 Amendment 3 of December 1982 Amendment 4 of December 1982 Amendment 5 of February 1986
EN 50018 (March 1977) (Edition 1)	<i>Electrical apparatus for potentially explosive atmospheres: Flameproof enclosure “d”</i> With: Amendment 1 of July 1979 Amendment 2 of December 1982 Amendment 3 of November 1985

CECC Standard referred to in European Standard EN 50020

CECC 50000:1977 (2nd edition)	<i>Harmonized system of quality assessment for electronic components — Generic specification: Discrete semiconductor devices</i>
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This European Standard has been prepared by the CENELEC Technical Subcommittee 31.3.

1 Scope

1.1 This European Standard contains the specific requirements for construction and testing of intrinsically safe electrical apparatus, type of protection “i”, intended for use in potentially explosive atmospheres.

1.2 This European Standard supplements European Standard EN 50014 “*General requirements*”, the requirements of which apply to intrinsically safe electrical apparatus and to associated electrical apparatus except as indicated in the following list (see also **1.2.1**).

Clause of EN 50014	Title of requirements	Clause excluded	
		Intrinsically safe electrical apparatus	Associated electrical apparatus
2.1	Electrical apparatus	YES	YES
4.1	Maximum surface temperature	NO	YES
4.3	Surface temperature and ignition temperature	NO	YES
5.2	Delay times for opening of enclosures	YES	YES
6.1	Definition of the material	YES	YES
6.2	Thermal endurance of plastics materials	YES	YES
6.3	Electrostatic charges of enclosures of plastics material	NO	YES
6.4	Threaded holes in enclosures of plastics material	YES	YES
7.1	Alloys used in light alloy enclosures	NO	YES
7.2	Threaded holes	YES	YES
8	Fasteners	YES	YES
9	Interlocking devices	YES	YES
10	Bushings	YES	YES
11	Materials used for cementing	YES	YES
12	Connections	YES	YES
14.1	Connection facilities	YES	NO
14.3	Terminal compartments	YES	YES
15	Cable and conduit entries	YES	YES
Section III	Supplementary requirements for certain electrical apparatus	YES	YES
22.4.3.1	Test for resistance to impact	YES	YES
22.4.5	Torque test for bushings	YES	YES
22.4.6.1	Temperature measurement (excluding the second paragraph commencing “The measured maximum surface temperature” and ending “T2 & T1”)	NO	YES
22.4.6.2	Thermal stability	YES	YES
22.4.7.1	Ambient temperature during tests	YES	YES
22.4.7.2	Tests of enclosures and parts of enclosures in plastics materials	YES	YES
22.4.7.3	Thermal endurance to heat	YES	YES
22.4.7.4	Thermal endurance to cold	YES	YES
22.4.7.5	Resistance to light	YES	YES
22.4.7.6	Resistance to chemical agents for Group I electrical apparatus	YES	YES

Clause of EN 50014	Title of requirements	Clause excluded	
		Intrinsically safe electrical apparatus	Associated electrical apparatus
22.4.7.7	Mechanical tests	YES	YES
22.4.7.8	Insulation resistance test of parts of enclosures of plastics materials	NO	YES
22.4.8	Tests in explosive mixtures (see 1.2.2)	NO	YES
22.4.9	Tests of clamping of non-armoured cables in cable entries	YES	YES
22.4.10	Tests of clamping of armoured cables in cable entries	YES	YES
Annex B	Example of test rig for impact test	YES	YES
Annex C	Methods of measurement of the insulation resistance of parts of enclosures of plastics materials	NO	YES
Annex D	Practical examples of legible and durable marking	YES	YES

1.2.1 If the associated electrical apparatus is protected by a type of protection listed in European Standard EN 50014 “*General requirements*” the requirements of that standard apply in the conditions of application of the European Standard for the type of protection concerned.

1.2.2 Associated electrical apparatus itself does not necessarily need to be tested in explosive mixtures, but any intrinsically safe circuits belonging to such apparatus shall be so tested.

1.3 This European Standard applies to electrical apparatus in which the electrical circuits themselves are incapable of causing explosion in the surrounding atmosphere.

1.4 This European Standard applies also to electrical apparatus or parts of electrical apparatus located outside the potentially explosive atmosphere or protected by another type of protection listed in European Standard EN 50014 “*General requirements*”, 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.

NOTE The permitted methods of interconnection of intrinsically safe electrical apparatus and associated electrical apparatus are specified in another European Standard (in preparation).

2 Definitions

The following definitions specific to type of protection intrinsic safety “i” are applicable in this European Standard; they supplement the definitions which are given in European Standard EN 50014 “*General requirements*”.

2.1

intrinsically safe circuit

a circuit in which no spark or any thermal effect produced in the test conditions prescribed in this standard (which include normal operation and specified fault conditions) is capable of causing ignition of a given explosive atmosphere

2.2

electrical apparatus

an assembly of electrical components, circuits or parts of circuits usually within a single enclosure

NOTE 1 The term “usually” has been introduced to indicate that an apparatus may occasionally be in more than one enclosure (for example, a telephone instrument or a portable radio transceiver with a hand microphone).

NOTE 2 This definition is more precise than that contained in European Standard EN 50014 “*General requirements*”.

2.3

intrinsically safe electrical apparatus

electrical apparatus in which all the circuits are intrinsically safe

2.4**associated electrical apparatus**

electrical apparatus in which the circuits are not all intrinsically safe but which contains circuits that can affect the safety of intrinsically safe circuits connected to it

NOTE Associated electrical apparatus may be

either electrical apparatus which has an alternative type of protection listed in European Standard EN 50014 “*General requirements*” for use in the appropriate potentially explosive atmosphere,
or electrical apparatus not so protected which shall therefore not be used within a potentially explosive atmosphere.

Example: A recorder which is not in a potentially explosive atmosphere, but which is connected to a thermocouple situated within a potentially explosive atmosphere where only the recorder input circuit is intrinsically safe.

2.5**normal operation**

intrinsically safe electrical apparatus or associated electrical apparatus is in normal operation when it conforms electrically and mechanically to its design specification and is used within the limits specified by the manufacturer

2.6**fault**

a defect of any component, or a defective connection between components, upon which the intrinsic safety of a circuit depends

NOTE 1 If a fault can lead to a subsequent fault or faults, the primary and subsequent failures are considered to be a single fault.

NOTE 2 The use of a spark test apparatus in the circuit to produce circuit interruptions, short circuits and earth faults is considered to be a test of normal operation.

2.7**self-revealing fault**

a fault which would cause some malfunction of electrical apparatus necessitating correction before proceeding with further operation of this, and which may be indicated, for example, by an audible or visual signal

2.8**non-self-revealing fault**

a fault which would not be evident to the user in the normal operation of an electrical apparatus

2.9**infallible component or infallible assembly of components**

a component, or an assembly of components, which is not liable to become defective, in service or in storage, in such a manner as to lower the intrinsic safety of the circuit. Such a component or assembly of components is considered as not subject to fault in that manner when tests of intrinsic safety are made

3 Grouping and classification of intrinsically safe electrical apparatus and associated electrical apparatus

Intrinsically safe electrical apparatus and associated electrical apparatus shall be placed in Group I or Group II as defined in European Standard EN 50014 “*General requirements*”.

For electrical apparatus placed in Group II, the subdivisions A, B, C specified in European Standard EN 50014 “*General requirements*” are also applicable.

Group II intrinsically safe electrical apparatus shall also be given a surface temperature classification in accordance with European Standard EN 50014 “*General requirements*”.

4 Categories of electrical apparatus

Intrinsically safe electrical apparatus and intrinsically safe parts of associated electrical apparatus shall be placed in one of two categories, “ia” or “ib”. The requirements of this standard apply to both categories, unless otherwise specified.

4.1 Category “ia”. Electrical apparatus of category “ia” shall be incapable of causing ignition in normal operation, with a single fault and with any combination of two faults applied, with the following safety factors:

- 1.5: in normal operation and with one fault;
- 1.0: with two faults.

For spark ignition the safety factor shall be applied to the current or voltage or a combination of these, as specified in 9.4.1.

For surface temperature classification a safety factor of 1.0 shall apply.

4.2 Category “ib”. Electrical apparatus of category “ib” shall be incapable of causing ignition in normal operation and with a single fault applied, with the following safety factors:

- 1.5: in normal operation and with one fault;
- 1.0: with one fault, if the apparatus contains no unprotected switch contacts in parts likely to be exposed to a potentially explosive atmosphere and the fault is self-revealing.

The safety factor shall be applied to the voltage or the current or a combination of these, as specified in 9.4.1.

For surface temperature classification a safety factor of 1.0 shall apply.

5 Constructional requirements

These requirements shall be applied as far as the intrinsic safety of the electrical apparatus is dependent on them.

5.1 Wiring. If the wiring of intrinsically safe electrical apparatus of temperature class T1 to T4 inclusive is copper and is in accordance with the requirements of Table 1 below, the temperature tests for the determination of its maximum surface temperature are not necessary.

Table 1 — Cross section/current relationship for copper wire

Cross-sectional area	mm ²	0.017	0.03	0.09	0.19	0.28	0.44
Maximum current	A	1.0	1.65	3.3	5.0	6.6	8.3
NOTE The cross section to be considered is that of the conductor of the wiring, that is, all strands of a conductor if it is a stranded conductor.							

5.2 Mounting of components. To prevent reduction of clearances, components shall be securely fixed. If a casting compound is used, care shall be taken to ensure that no damage to the components or connections occurs during the process of encapsulation.

5.3 Outer enclosures. Components and wiring of intrinsically safe electrical apparatus and associated electrical apparatus shall be protected against unauthorized interference so far as is necessary to prevent such interference resulting, either directly or indirectly, in an unsafe condition. Where an enclosure is necessary for this purpose, it shall provide a degree of protection not less than IP 20 as defined in IEC 144.

NOTE Although this requirement allows the construction of electrical apparatus without an enclosure, for example, strain gauges or thermocouples, an enclosure will usually be necessary especially for Group I apparatus. The degree of protection may vary according to the intended use; for example, a degree of protection of IP 54 as defined in IEC 144 may be required on a coal face under humid and dusty conditions.

5.4 Facilities for connection of external circuits

5.4.1 Terminals. Terminals for connection of external circuits to intrinsically safe electrical apparatus and associated electrical apparatus shall be so arranged that components are not damaged when making connections.

Terminals for intrinsically safe circuits shall be at least 50 mm from terminals or uninsulated conductors of any non-intrinsically safe circuits or shall be separated from them by an insulating or earthed metal barrier. Where such separating barriers are used, they shall extend to within 1.5 mm of the walls of the enclosure, or alternatively provide a minimum measurement of 50 mm between the terminals when taken in any direction around the barrier. The barrier shall have a thickness appropriate to the material used with a minimum of 0.9 mm for non-metallic barriers, 0.45 mm for metal barriers.

The minimum clearances between terminals of intrinsically safe circuits and any earthed metal shall be 3 mm, unless that terminal is intended to be earthed.

The clearance between two terminals of different intrinsically safe circuits shall be at least 6 mm.

5.4.2 Plugs and sockets. Where plugs and sockets are used for connection of external circuits, the plugs and sockets for intrinsically safe circuits shall be separate from, and non-interchangeable with, other plugs and sockets, except where no hazard can arise from an interchange, or plugs and sockets are so identified that incorrect connection is improbable.

For special applications, intrinsically safe and non-intrinsically safe circuits are permitted in the same plug and socket assembly, provided that it is of an acceptable design and that intrinsic safety is not required when the other circuits are energized.

5.4.3 Permanently connected cables. Contrary to 14.1 of EN 50014 “General requirements”, Group I electrical apparatus which is not portable may be constructed with a permanently connected cable.

5.5 Separation of conductive parts. Separation of conductive parts shall be in accordance with 5.5.1 to 5.5.11 in order to provide protection against voltages in other conductors within the apparatus (see, for example, Figure 2).

Separating distances shall be measured or assessed taking account of any likely movement of the conductors and manufacturing tolerances shall not reduce these distances by more than 10 % or 1 mm whichever is the smaller.

If the minimum values specified in Table 2 are satisfied, these distances shall be considered infallible.

Smaller distances, which exceed one-third of the values specified in Table 2, shall be considered as faults subject to the requirements of 4.

If distances are less than one-third of the values specified in Table 2, the conducting parts shall be considered to be in permanent contact where this would produce a less safe condition.

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

- part of the same circuit which is not intrinsically safe; or
- non-intrinsically safe circuits; or
- other intrinsically safe circuits; or
- earthed metal parts, where contact would affect intrinsic safety.

The value of voltage to be considered is either a) or b) following.

a) *For separate circuits.* The difference between the peak values of the following voltages:

- 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 may 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 occur during fault conditions defined in 4 shall, where applicable, be used to determine the maximum value.

Table 2 — Clearance, creepage distances and separations

1	Voltage (peak value)	V	10	30	60	90	190	375	550	750	1 000	1 300	1 575	3,3 kV	4,7 kV	9,5 kV	15,6 kV
2	Clearance	mm	1,5	2	3	4	5	6	7	8	10	14	16			See Note	
3	Separation distances through encapsulant	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 distance (in air)	mm	1,5	2	3	4	8	10	15	18	25	36	40			See Note	
6	Creepage distance (under coating)	mm	0,5	0,7	1	1,3	2,6	3,3	5	6	8,3	12	13,3			See Note	
7	Comparative tracking index	ia CTI	90	90	90	90	175	175	275	275	275	275	275			See Note	
		ib CTI	90	90	90	90	175	175	175	175	175	175	175				

NOTE Except for separation distances, no values for voltages of 3,3 kV and over are proposed at present.

5.5.2 Clearance. Clearance is the shortest distance in air between two conductive parts. In measuring or assessing this distance, insulating parts of less than 0.9 mm thickness, which are not otherwise physically supported, should be ignored.

The clearance shall be determined in accordance with Table 2 for the relevant voltage. For voltages higher than 1 575 V peak, an interposing insulating barrier or earthed metal barrier shall be used.

5.5.3 Separation distances through encapsulant (encapsulant assemblies). Separation distances through encapsulating compounds are the shortest direct line distances between conductive parts which are totally encapsulated. This includes distances within encapsulation between conductive parts, which are mechanically fixed on insulating boards such as the tracks on printed circuit boards.

The encapsulating compound may be:

- a hard material (e.g. epoxy resin). In this case no additional protection is necessary; or
- a soft material (e.g. silastomeric). In this case an enclosure or a covering of hard encapsulant shall be used.

The encapsulating compound shall:

- a) have a temperature rating, specified by the manufacturer of the material or apparatus, which is at least equal to the maximum temperature achieved by any component under encapsulated conditions unless it can be shown that component temperatures higher than the rated encapsulant do not cause any damage to the encapsulant that would adversely affect the type of protection;
- b) have at its free surface a CTI value of at least that specified in Table 2 if any bare conductive parts protrude from the encapsulant;
- c) be adherent to all conductive parts, components and substrates except when they are totally enclosed by the encapsulant;
- d) be specified by its generic name and the type designation given by the manufacturer.

The required separation distance shall be determined from Table 2 for the relevant voltage.

The failure of a component which is encapsulated or hermetically sealed (e.g. a semi-conductor), used in accordance with 6.1 and in which internal clearances and distances through encapsulant are less than one-third of the values given in line 3 of Table 2 is to be considered as a single fault subject to the requirements of 4.

The minimum separation distance between encapsulated conductive parts and components, whether intrinsically safe or not, and the free interface of the encapsulant, shall be at least half the values shown in line 3 of Table 2 with a minimum separation distance of 1 mm.

The circuits connected to the encapsulated conductive parts and/or components shall be intrinsically safe when the encapsulated conductive parts and/or components are part of intrinsically safe electrical apparatus. The minimum separation distance of 1 mm is not applicable when the encapsulant is in direct contact with an enclosure of insulating material complying with the requirements of line 4 of Table 2 (see Figure 4).

The insulation of the encapsulated circuit shall comply with the electric strength test requirements of 5.5.12.

5.5.4 Separation distances through solid insulation. The separation distance is the shortest distance between two conductive parts measured directly through insulation. For composite separations see 5.5.5.

The insulation shall have a dielectric property which will allow the insulation requirement of 5.5.12 to be met for the separation distance specified in Table 2.

NOTE 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 a single insulator.

The required separation distance shall be determined from Table 2 for the relevant voltage.

5.5.5 Composite separations. Where separations are composite (for example part through air and part through insulation), the total separation shall be calculated on the basis of referring all separations to one line of Table 2.

For example at 60 V:

Clearance (line 2) = $6 \times$ separation through solid insulation (line 4)

Clearance (line 2) = $3 \times$ separation through encapsulant (line 3)

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

To be infallible the above result shall be not less than the clearance value specified in Table 2.

Any clearance or separation which is below one-third of the relevant value specified in Table 2 shall be ignored for the purposes of calculation.

5.5.6 Creepage distance (in air). Creepage distance (in air) is the shortest distance along the surface of an insulating material between two conductive parts. The method of measuring or assessing these distances is to be in accordance with Figure 3.

In the case of Figure 3(k), the rib must be bonded with a material which has equivalent insulation properties.

The creepage distance shall be determined in accordance with Table 2 for the relevant voltage.

The creepage distance may be made up from the addition of shorter distances where, for example, a conductive part which is not connected to a circuit or to earth is interposed. In this case distances of less than one-third of the relevant value in line 5 of Table 2 shall not be taken into account. For voltages higher than 1 575 V peak, an interposing insulating barrier or earthed metallic barrier shall be used.

5.5.7 Creepage distance (under coating). The creepage distance under a coating is the shortest distance between two conductive parts along the surface of the interface between an insulating material and an applied conformal coating.

The conformal coating shall be applied in two separate coats, and shall have the effect of sealing the conductive parts against ingress of moisture. It shall adhere to the conductive parts and to the insulating material.

The creepage distance shall be determined from Table 2 for the relevant voltage.

5.5.8 Comparative tracking index (CTI). For the creepage distance (in air) specified in line 5 of Table 2, the insulating material shall comply with the requirements of line 7 of Table 2 which specifies the minimum comparative tracking index (CTI) according to the test prescribed in IEC 112.

5.5.9 Requirements for assembled printed circuits. Circuits or parts of circuits (see Figure 5) for which the determination of creepage distances is required shall meet the requirements of 5.5.1 to 5.5.12 as specified in a) and b) below.

a) When a printed circuit is covered by a coating according to 5.5.7 the requirements of 5.5.2 and 5.5.6 apply only to those parts which lie outside the coating, for example:

- parts with 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 5.5.7 will apply:

- to the separation distance between tracks which are covered with an epoxide type solder resist coating. A single coating of this type shall be considered as equivalent to a conformal coating applied in two separate coats;
- to circuits or parts of circuits and their fixed components provided that the coating covers the connecting pins, solder joints and the conductive parts of any components for which consideration of the separation distance is necessary.

5.5.10 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 adequate to carry the maximum possible current to which it could be continuously subjected under the requirements of 4. Connection through a connector comprising at least three independent connecting elements for ia and two for ib shall be considered infallible. These elements shall be connected in parallel (see Figure 6). Where the connector can be removed at an angle one connection shall be present at, or near to, each end of the connector.

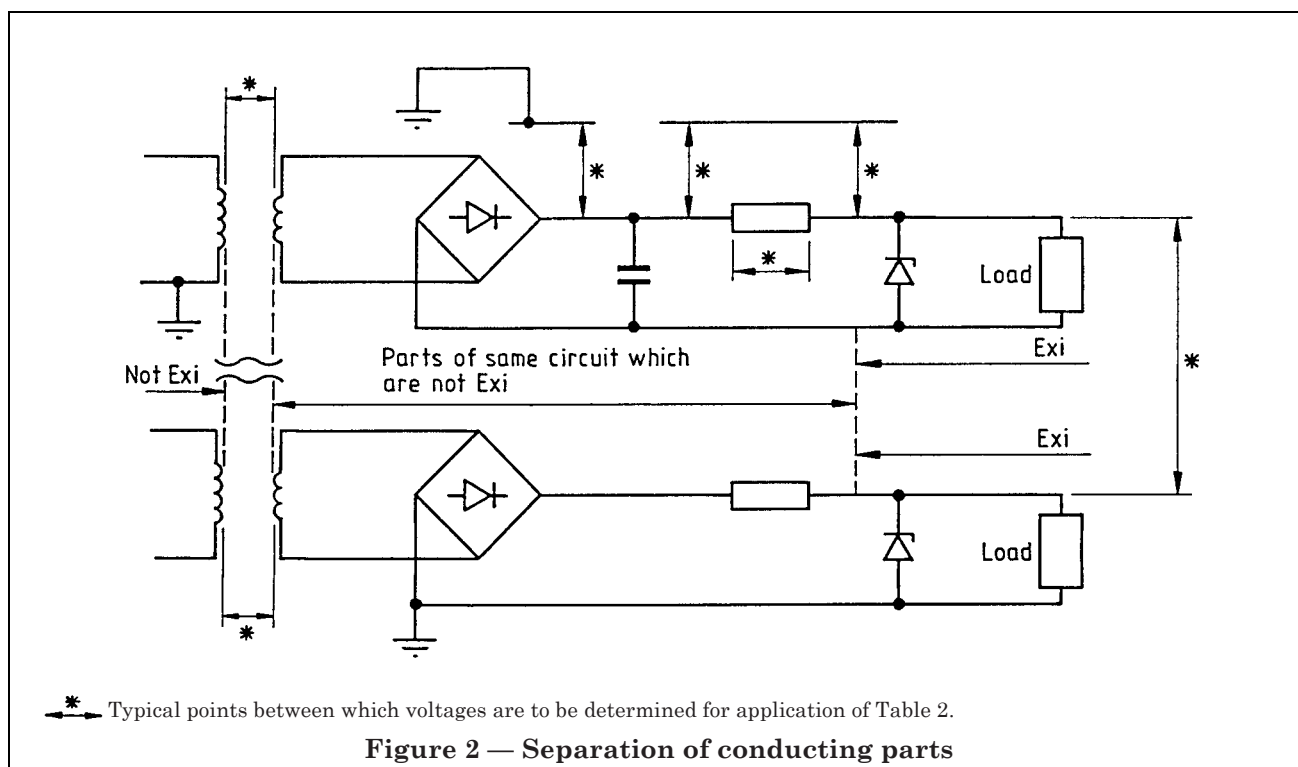
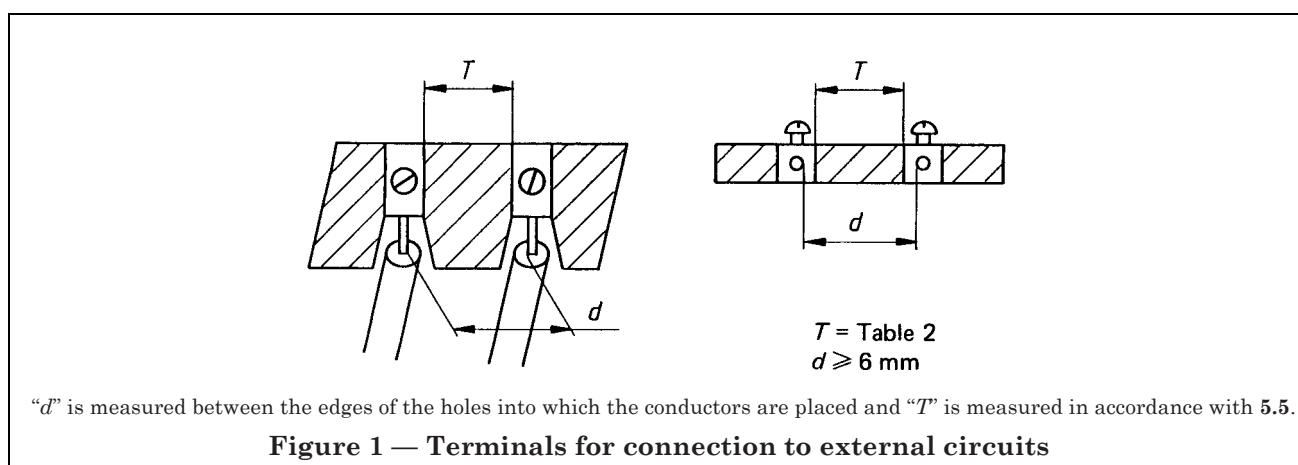
5.5.11 Internal wiring. Insulation, except for varnishes and enamels, covering the conductors of internal wiring shall be considered as solid insulation (see 5.5.4) for the purposes of this standard.

5.5.12 Electric strength tests. The insulation between an intrinsically safe circuit and the frame of the electrical apparatus or parts which may be earthed shall be capable of withstanding a 50–60 Hz, r.m.s., ac test voltage of twice the voltage of the intrinsically safe circuit or 500 V whichever is the greater.

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

5.5.13 Relays and switches. In normal operation, the currents and voltages switched by contacts in non-intrinsically safe circuits shall not exceed 5 A r.m.s. and 250 V r.m.s. respectively. The contacts shall not switch more than 100 VA.

For higher values, intrinsically safe circuits and non-intrinsically safe circuits shall only be connected to the same relay if they are separated by an earthed metal barrier or an insulating barrier. 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 2. When the values switched by the contacts do not exceed 10 A and/or 500 VA, it is sufficient to double the values for creepage distance and clearance from Table 2 for the relevant voltage.



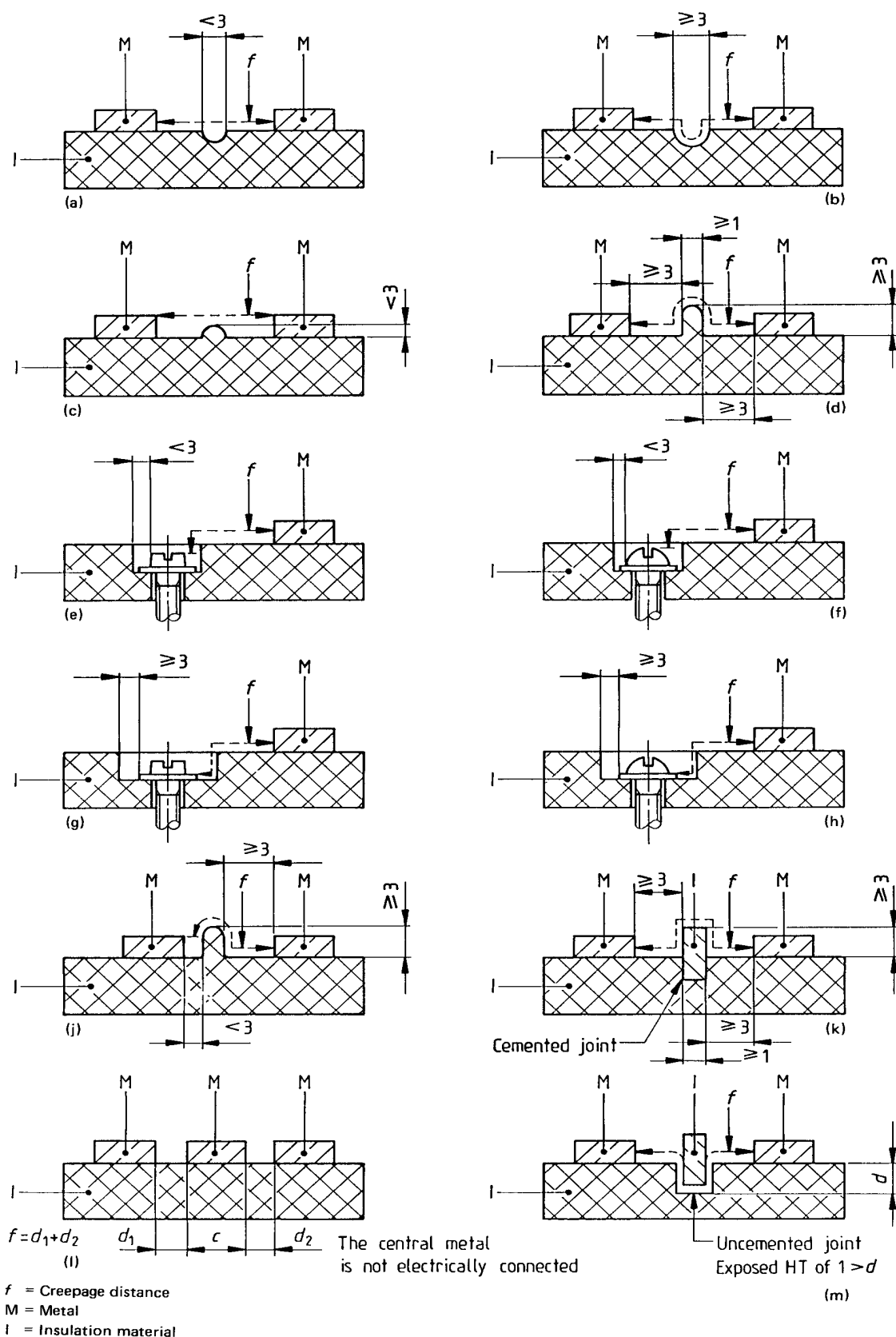


Figure 3 — Determination of creepage distances (in air)

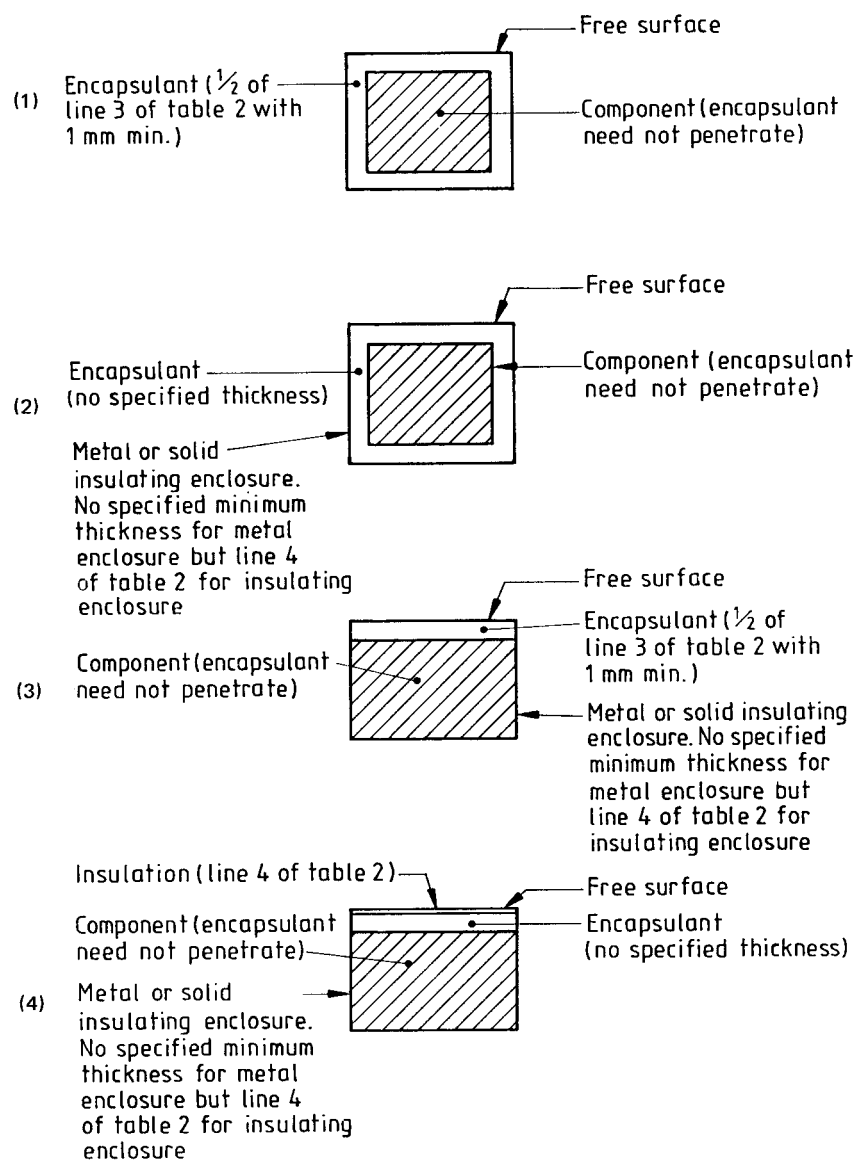
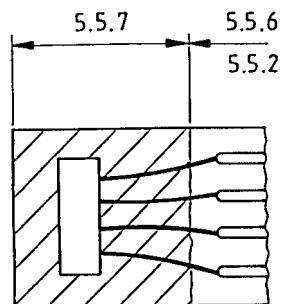
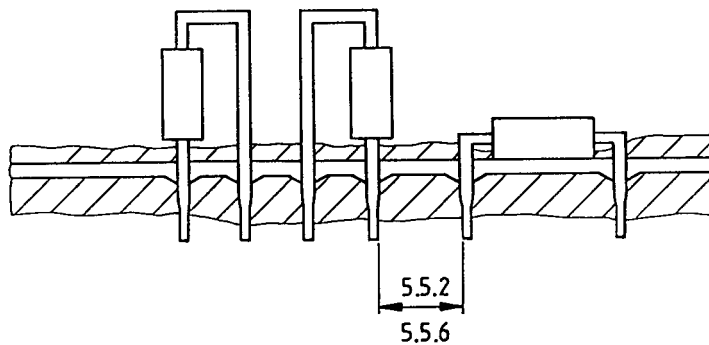


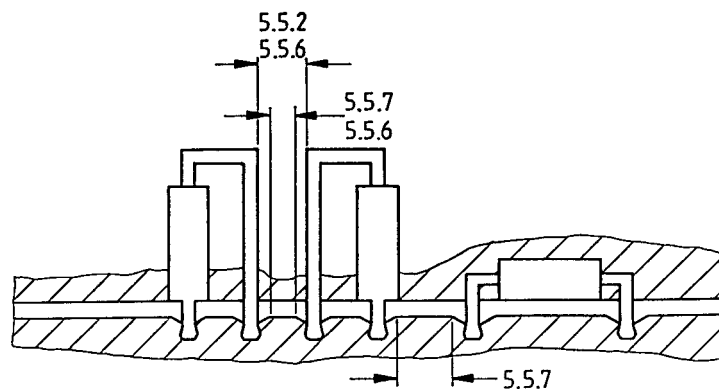
Figure 4 — Application of 5.5.3 for encapsulated assemblies



a) Resistor leads not sealed within coating therefore 5.5.2 and 5.5.6 apply

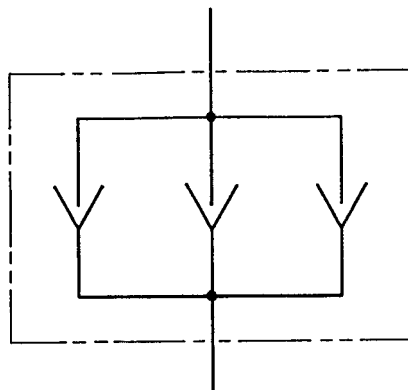


b) Solder pins protruding

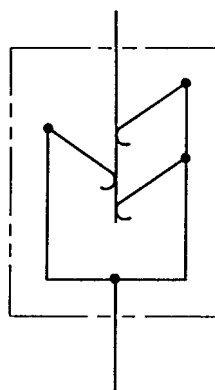


c) Solder pins folded or cropped

Figure 5 — Creepage distances and clearances on printed circuit boards



a) Example of 3 completely independent connecting elements



b) Example of 3 connecting elements which are not independent

Figure 6 — Examples of independent and non-independent connecting elements

5.6 Earthing. Where earthing of such conductors as metal screens, printed circuit board conductors, segregation contacts of plug-in connectors and diode safety barriers is required for safety reasons, the cross-sectional area of the conductors, connectors and terminals shall be adequate to carry the maximum possible current to which they could be continuously subjected under the fault conditions referred to in clause 4.

Connectors and terminals shall be designed to maintain contact pressure on and resist loosening of the earth connection by vibration.

If earthing of an intrinsically safe circuit is necessary for functional or safety purposes, the method of earthing shall be such as to avoid adverse effects on the intrinsic safety of the circuits.

5.7 Insulation. The insulation between an intrinsically safe circuit and the frame of the electrical apparatus or parts which may be earthed shall 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.

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 $2U + 1\,000$ V with a minimum of 1 500 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.

5.8 Internal wiring. The layout of wiring in the electrical apparatus shall be such that induction of dangerous voltages and currents into the intrinsically safe circuit, by inductive and capacitive pick-up, is improbable.

5.8.1 Insulation of conductors. Intrinsically safe circuits shall be wired with conductors having a grade of insulation capable of withstanding an r.m.s. a.c. test voltage of twice the voltage of the intrinsically safe circuit with a minimum of 500 V.

Non-intrinsically safe circuits in the same enclosure as intrinsically safe circuits shall be wired with conductors having a grade of insulation capable of withstanding an r.m.s. a.c. test voltage of $2U + 1\,000$ V with a minimum of 1 500 V, 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.

5.8.2 Separation between the conductors of the cores. 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 at least equal to the appropriate value in line 7 of Table 2 except when:

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 2 000 V.

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

6 Components on which intrinsic safety depends

6.1 Rating of components. All components on which intrinsic safety depends, except transformers, shall not operate, including under the fault conditions defined by clause 4, at more than $\frac{2}{3}$ of their rated current or voltage or power as appropriate, in the ambient temperature prescribed in European Standard EN 50014 “*General requirements*”. The mounting conditions are those specified by the manufacturer of the electrical apparatus. These rated values shall be those specified by the manufacturer of the component.

6.2 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 they are identified in such a manner that incorrect connection is improbable.

6.3 Cells, batteries and accumulators. Any cell, battery or accumulator which requires current-limiting devices for safety and which is intended for use in a potentially explosive atmosphere shall be encapsulated or enclosed with its current-limiting devices in such a way that any conductor or terminal, other than the output terminals of the assembly or terminals intended for recharging, shall not be accessible:

if the cell, battery or accumulator is intended to be changed in a potentially explosive atmosphere, it shall form a complete replaceable unit with its current-limiting devices;

if the cell, battery or accumulator is not intended to be changed in a potentially explosive atmosphere, it may alternatively be housed in a compartment with special fasteners, for example those required by European Standard EN 50014 “*General requirements*”. The housing shall then carry a warning label.

There shall not be any temperature rise of the assembly, or any emission of flammable gas, which could produce an unsafe condition, or any abnormal distortion of the cell, battery or accumulator on continued short circuit of the output terminals either with the current-limiting device in circuit or when the fault conditions appropriate to clause 4 are applied.

Cells, batteries or accumulators shall be of a type from which there can be no spillage of electrolyte, or be placed in a special container which prevents attack of the circuits by the electrolyte.

The above requirements still apply where the assembly is housed in a flameproof enclosure in accordance with European Standard EN 50018 “*Flameproof enclosure*”.

Protection against the withdrawal of current from recharging terminals shall be provided where necessary, for example by the use of series diodes.

6.4 Semiconductors

6.4.1 Semiconductors may be used as shunt voltage limiting devices provided that any possible transient conditions are taken into account.

Semiconductors used for this purpose shall be capable of carrying, without open circuiting, the current which would flow at their place of installation if they failed in the short circuit mode.

6.4.2 Semiconductors may be used as series current-limiting devices only in category “ib” apparatus.

NOTE The use of semiconductors as current-limiting devices is not permitted for category “ia” apparatus because of their probable future use in areas in which a continuous or frequent presence of an explosive atmosphere may coincide with the possibility of a brief transient which could cause ignition. This requirement does not preclude the use of series-blocking diodes in circuits of category “ia”.

7 Infallible components and infallible assemblies of components

In intrinsically safe electrical apparatus and associated electrical apparatus, components or assemblies of components complying with the requirements of this clause shall be considered infallible.

7.1 Mains transformers

7.1.1 Protective measures. The input circuit of mains transformers intended for supplying intrinsically safe circuits shall be protected by a fuse or circuit breaker; measures shall be taken to permit its connection to a network with a prospective short circuit current of 4 000 A. The rated current of a fuse shall be indicated in a position adjacent to the fuse.

If the input and output windings are separated by an earthed metal screen (see **7.1.2**, type 2b construction), each non-earthed input line shall be protected by a fuse or circuit breaker.

NOTE 1 A fuse or circuit breaker having a rated current not exceeding three times the rated input current of the transformer is recommended.

NOTE 2 Additionally an embedded thermal fuse or other thermal device may be used for protection against overheating of the transformer.

7.1.2 Transformer construction. All windings for supplying intrinsically safe circuits shall be separated from all other windings by one of the types of construction specified below.

Type 1 construction: by placing them either

- a) on one leg of the core, side by side in separate bobbins or separate sections of the same bobbin, or
- b) in bobbins on different legs of the core.

Type 2 construction: by winding them one over another with either

- a) insulation between the windings complying with type test 2 (see **7.1.3.2**), or
- b) an earthed screen between the windings made of copper foil or an equivalent wire winding (wire screen).

The thickness of the copper foil or the wire screen, as the case may be, shall be so chosen that in the event of a short circuit between any winding and the screen, the latter will be able to withstand, without breakdown, the current which flows until the fuse or circuit breaker functions (see Table 3).

Table 3 — Minimum foil thickness or minimum wire diameter of the screen in relation to the rated current of the fuse

Fuse rating	A	0.1	0.5	1	2	3	5
Minimum thickness of foil screen	mm	0.05	0.05	0.075	0.15	0.25	0.3
Minimum diameter of the wire of the screen	mm	0.2	0.45	0.63	0.9	1.12	1.4

The foil screen shall be provided with two mechanically separate leads to the earth connection, each of which is capable of withstanding, without damage, the current which could flow before the fuse or circuit breaker operates.

A wire screen shall consist of at least two electrically independent layers of wire, each of which is provided with an earth connection and is capable of withstanding, without damage, the current which could flow before the fuse or circuit breaker operates.

The cores of all mains supply transformers shall be provided with an earth connection, except where earthing is not practicable, as with insulated toroidal core transformers used in d.c.-to-d.c. converters.

The transformer shall be impregnated as defined in IEC 85 in order to consolidate the windings.

7.1.3 Mains transformer type tests. The transformer together with its associated devices (e.g. fuses, circuit breakers, thermal devices and resistors) shall maintain a safe electrical isolation between the power supply and the intrinsically safe circuit even if any one of the output windings is short circuited and all other output windings are subjected to their maximum electrical loading.

The above requirement is satisfied if the transformer passes one of the appropriate type tests described below and subsequently withstands a test voltage (see 9.5) of $2U_n + 1\,000\text{ V r.m.s.}^{1)}$ or $1\,500\text{ V}$, whichever is the greater, between any windings used to supply intrinsically safe circuits and all other windings.

7.1.3.1 Type test for mains transformers of type 1a, 1b and 2b construction. The transformer output windings are short circuited or loaded as described in 7.1.3 in such a way as to obtain the largest input current. The input current is then adjusted to $1.7I_n$ (where I_n is the current rating of the fuse) or to the maximum non-instantaneous tripping current of the circuit breaker by adjustment of the input voltage. If the input voltage necessary is larger than the rated input voltage, then the test shall be carried out at the rated input voltage.

The temperature rise of the transformer shall not exceed the permissible value for the class of insulation employed either in continuous operation for at least 6 h or up to the moment when the thermal trip functions if such a device is incorporated with the transformer. However, it is permissible for the temperature of the windings of type 2b construction transformers to exceed the permissible value when insulation from earth of the intrinsically safe circuit is not required.

If an output winding is fitted with a current-limiting resistor so arranged that the winding cannot be directly short circuited, the test shall be carried out with the resistor in circuit.

NOTE 1 The temperature rise in the transformer is usually determined by measuring the increase in electrical resistance of the windings.

NOTE 2 The classes of insulation and their corresponding limiting values of temperature are defined in IEC 85.

7.1.3.2 Type test for mains transformers of type 2a construction. The test is carried out in the same way as described in 7.1.3.1 except that the input winding is subjected to its rated input voltage and the input current is not limited.

The transformer may withstand the test for the 6 h or fail. Either the input winding or output winding, or windings, may short circuit to the core during this test, but after the test the transformer shall comply with the voltage test as described in 7.1.3.

The transformer shall not burst into flames during the test.

7.1.4 Routine tests of mains transformers. Each mains transformer shall be subjected to the test voltages given in Table 4.

Table 4 — Routine test voltages for mains transformers

Where applied	R.M.S. test voltage
Between input and output windings	$4U_n^a$ or $2\,500\text{ V}$, whichever is greater
Between all the windings and the core or screen	$2U_n^a$ or $1\,000\text{ V}$, whichever is greater
Between each winding which supplies an intrinsically safe circuit and any other output winding	$2U_n^a + 1\,000\text{ V}$ or $1\,500\text{ V}$, whichever is greater

^a U_n = the highest rated voltage of any winding under test.

During these tests there shall be no breakdown of the insulation between windings or between any winding and the core or screen.

7.2 Transformers other than mains transformers. These transformers can be either transformers, such as those used for inverter supply units operating from batteries, or coupling transformers such as those used in signal circuits.

The construction and testing of these transformers shall be based on the requirements of 7.1 modified according to their application. However, the routine test voltage between the input and output windings given in Table 4 shall be reduced to $2U_n + 1\,000\text{ V r.m.s.}$ or $1\,500\text{ V r.m.s.}$, whichever is the greater.

7.3 Damping windings. Damping windings shall be of reliable mechanical construction, for example seamless metal tubes or windings of bare wire continuously short circuited by soldering, or the equivalent.

¹⁾ U_n is the highest nominal voltage of any winding under test.

7.4 Current-limiting resistors. Current-limiting resistors shall be either film type or of the wire wound type with protection to prevent unwinding of the wire in the event of breakage.

7.5 Capacitors. Capacitors shall be of a high reliability type and shall form an assembly comprising at least two capacitors mounted in series. Electrolytic or tantalum capacitors shall not be used.

Each capacitor shall be capable of withstanding a dielectric test using an a.c. voltage of $2U + 1\,000\text{ V}$ r.m.s. (U is the highest voltage which can appear between the terminals of the assembly).

Where an assembly of capacitors is connected between two separate intrinsically safe circuits or between two parts of the same intrinsically safe circuit, and where the highest voltage which can appear between the terminals of the assembly is less than 90 V, it is sufficient that each capacitor shall be capable of withstanding a dielectric test using an a.c. voltage of 500 V r.m.s.

7.6 Safety shunts. Components used as safety shunts shall be of a type in which the most probable mode of failure is to short circuit and shall form an assembly of at least two components mounted in parallel.

They shall be connected in such a manner that they are not liable to become disconnected (e.g. by being mounted close to the circuit which is being protected and encapsulated with it) or so that the disconnection of either of the shunt components ensures that the circuit being protected becomes disconnected at the same time.

Safety shunts may be used for:

- Limitation of energy discharged from devices such as inductances or piezo-electric devices;
- Limitation of voltage to energy storing devices such as capacitors;
- Limitation of voltage in energy sources when such sources are fed from an infallible transformer complying with 7.1 or a barrier device complying with 8 or a battery.

These safety shunts may conduct in normal operation.

NOTE Bridge-connected diodes are accepted as duplicated shunt components.

7.7 Connections in infallible assemblies. Where components forming part of infallible assemblies are joined by conductors the following are considered as infallible:

- Two parallel wires or two parallel printed circuit tracks or a combination of one wire and one printed circuit track.
- Two parallel soldered or similar joints. Where a wire is more than 6 cm long it shall be restrained close to the joint (e.g. by passing through a printed circuit board or by the use of adhesive) to avoid damage to the joint by movement of the wire or vibration.

7.7.1 Printed circuit tracks. Printed circuit tracks used in infallible assemblies shall be formed from copper cladding of nominal thickness of at least 0.035 mm (275–335 grams/sq. metre — IEC 249-HD 313). They shall also have a nominal width corresponding to at least four times the cross sectional area specified in Table 1 for the relevant maximum current.

If, in addition, the track width is greater than 2 mm and greater than 1 % of its length then it need not be duplicated and a single track shall be considered as infallible.

8 Diode safety barriers

8.1 General. Assemblies of fuse- or resistor-protected shunt diodes or zener diodes may be used as safety barriers between intrinsically safe and non-intrinsically safe circuits.

When such barriers comply with the following requirements, they shall be considered as infallible assemblies.

Barriers for electrical apparatus of category “ia” shall have

- either at least two diodes which conform to the type tested diodes in conforming to level of quality assessment L of specification CECC 50000 and have been subjected to the routine test described in 8.5.2,
- or at least three diodes.

Barriers for electrical apparatus of category “ib” shall have at least two diodes.

NOTE Barriers for use with electrical apparatus of category “ia” should be earthed unless they are isolated from mains supplies by a transformer conforming to the requirements of 7.1.

8.2 Protective measures. The input circuit of barriers shall be suitable for connection to a network having the maximum voltage for which the barrier is designed and in which the prospective short circuit current is 4 000 A.

8.3 Rating of barrier components. The diodes and resistors used in barriers shall comply with the requirements of 6.1.

The current-limiting resistors shall be infallible (see 7.4).

8.3.1 Barriers protected by resistors. The protecting resistors shall withstand, in the conditions specified in 6.1, the current which will flow through them when the voltage marked U_M (see 10.2) on the barrier is applied and when the diodes are assumed to be short circuited.

Each diode shall be capable of withstanding the above current without becoming open circuit.

8.3.2 Barriers protected by fuses. Each diode shall withstand, in the conditions specified in 6.1, a continuous current of $1.7 I_n$ (where I_n is the current rating of the fuse) and any transient which can occur when the barrier is connected to a supply having the maximum voltage for which the barrier is designed and a prospective short circuit current of 4 000 A.

8.4 Construction. The construction shall be such as to prevent incorrect mounting or to make incorrect mounting obvious (e.g. by being obviously asymmetrical about the mounting studs).

8.4.1 Facilities for connection to earth. The barrier shall have one earth connection facility in addition to the connection facilities for the circuit which may be at earth potential. This connection facility shall comply with 5.6.

8.4.2 Separation of connection facilities. The non-earthed connection facilities for the intrinsically safe circuit shall comply with 5.4.1 and shall be protected to prevent accidental contact with other conductors.

8.4.3 Protection of components. The assembly of components constituting a barrier shall be encapsulated in a single block (see 5.5.4).

8.5 Routine tests

8.5.1 Completed barriers. A routine test shall be carried out on each completed barrier to check correct operation of each diode and the value of the current-limiting resistor.

8.5.2 Diodes for 2-diode “ia” barriers

8.5.2.1 Storage temperature test. Each diode shall be subjected to a temperature of 150 °C, whilst not connected to any supply source, for 2 h. After cooling there shall be no deterioration of performance.

8.5.2.2 Pulse current test. Each diode shall be subjected in the direction of utilization (for zener diodes the zener direction) to a series of rectangular current pulses or capacitive discharges of 50 µs duration at a frequency of 50 Hz for 5 s. The peak current (or mean current if the pulse is not rectangular) is defined by the division of the voltage marked U_M (see 10.2) by the sum of the value (at 20 °C) of the fuse resistance if it is not susceptible to arcing, and any series resistances.

At the end of the tests the voltage shall not have changed by more than 1 % or 0.1 V, whichever is greater.

9 Type tests for electrical apparatus

Intrinsically safe electrical apparatus and associated electrical apparatus shall be subjected to a type test to ensure that the intrinsically safe circuits are incapable of causing ignition under the conditions specified in clause 4 for the appropriate category of electrical apparatus and for the appropriate group or groups specified in clause 3.

A circuit may only be exempted from a type test on the spark test apparatus if its structure and its electrical parameters are sufficiently well defined so that its safety may be deduced from the ignition curves in Annex A.

Similarly, intrinsically safe electrical apparatus may only be exempted from a surface temperature type test if its structure and electrical parameters are sufficiently well defined so that its maximum surface temperature can be derived from these.

9.1 Spark test apparatus. The spark test apparatus shall be that described in Annex B. In circumstances where the limiting values in Annex B are exceeded, an alternative test apparatus of corresponding sensitivity may be used at the discretion of the testing station.

9.2 Test mixtures. Generally the following test mixtures, in volumetric ratio with air and at atmospheric pressure, shall be used:

- Group I: (8.3 ± 0.3) % methane
- Group IIA: (5.25 ± 0.25) % propane
- Group IIB: (7.8 ± 0.5) % ethylene
- Group IIC: (21 ± 2) % hydrogen

In special cases electrical apparatus which is to be certified and marked for use in a specified gas or vapour shall be tested in the most easily ignited mixture of that gas or vapour with air.

9.3 Calibration of the spark test apparatus. The sensitivity of the spark test apparatus shall be checked before and after each test series carried out in accordance with 9.4. For this purpose the test apparatus shall be calibrated using one of the two following circuits:

- either a 24 V d.c. circuit containing a 0.095 H air-cored coil;
- or a 24 V d.c. resistive circuit (Inductance $< 10 \mu\text{H}$).

The currents in these circuits shall be set at the value given in Table 5 for the appropriate group.

The calibration circuit chosen shall be that which is most appropriate to the circuit which is to be tested.

The spark test apparatus shall be run for up to 400 revolutions of the tungsten wire holder, with the holder connected to the positive of the supply. The sensitivity shall be considered to be satisfactory if one ignition of the test mixture occurs.

9.4 Tests with the spark test apparatus. The spark test apparatus shall be inserted in the circuit under test at each point where it is considered that an interruption, short circuit or earth fault may occur, taking into account the requirements of this European Standard. Tests shall be made with the circuit in normal operation, and also with one or two faults, as appropriate to the category of electrical apparatus (see clause 4), and with the maximum values of the external capacitance and inductance for which the apparatus is designed.

Table 5 — Current in calibration circuit

Group	Inductive circuit		Resistive circuit	
	Cadmium disc	Other discs	Cadmium disc	Other discs
I	110 mA	160 mA	1.5 A	3.6 A
IIA	100 mA	125 mA	1.0 A	2.75 A
IIB	65 mA	100 mA	0.7 A	2.0 A
IIC	30 mA	52 mA	0.3 A	1.65 A

Account shall also be taken of the permissible variations of supply voltage (see European Standard EN 50014 “*General requirements*”), the specified tolerances of components and the effects of variation of ambient temperature (contrary to European Standard EN 50014 “*General requirements*”), between 0 and 40 °C, unless otherwise specified.

The test series at each test point shall continue for not less than 200 revolutions of the tungsten wire holder, with each polarity, for a d.c. circuit, or 1 000 revolutions for an a.c. circuit.

9.4.1 Safety factors. The safety factor required in clause 4 may be achieved by the following methods as appropriate or by any other method of equivalent severity, for example, by using a more severe test mixture.

When the test series is being carried out with faults applied to the circuit, the safety factor shall be applied to the values of current and voltage which arise under the fault conditions.

Where easily adjustable voltage tapplings are provided on the electrical apparatus, the prescribed safety factor shall exist when the maximum input voltage for which the electrical apparatus is designed is applied to the minimum voltage tapping.

9.4.1.1 Inductive circuits ($L > 1 \text{ mH}$). The current shall be increased by the required safety factor by reducing the value of limiting resistance, if possible, but otherwise by increasing the voltage.

9.4.1.2 Resistive circuits ($L \leq 1$ mH). The current shall be increased by the required safety factor by increasing the maximum possible value of all supply voltages by 10 % taking into account manufacturing tolerances, temperature effects and a 10 % variation of the mains supply; and increasing by 10 % the value of the maximum voltage which can be permitted by any voltage-limiting device (e.g. zener diode) in service taking into account manufacturing tolerances and temperature effects; and then decreasing the value of limiting resistance to obtain the necessary value of test current (when more than one current-limiting resistor exists, all such resistors shall be decreased in the same proportion). Where this is not possible the necessary value of test current may be achieved by a further increase in the voltage.

9.4.1.3 Capacitive circuits. The voltage shall be increased by the required safety factor. Where a current-limiting resistor meeting the requirements of 7.4 is used, the capacitor may alternatively be considered as a source of constant voltage and the safety factor may be achieved as prescribed in 9.4.1.2.

9.4.2 Result of spark tests. The electrical apparatus shall be considered to satisfy the spark test requirements if no ignition occurs in any test series at any of the chosen test points.

9.5 Voltage test. When a voltage test is required by this European Standard, the method shall be appropriate to the type of electrical apparatus concerned, for example those of IEC 348.

Where no appropriate method is available, the test shall be made with an alternating voltage of substantially sinusoidal wave form at a frequency between 48 Hz and 62 Hz. The supply shall be derived from a transformer of at least 500 VA output.

The voltage shall be increased steadily to the specified value in a period not less than 10 s and then maintained for at least 60 s.

10 Marking

10.1 Marking of electrical apparatus. Intrinsically safe electrical apparatus and associated electrical apparatus shall carry at least the minimum marking prescribed in European Standard EN 50014 “General requirements”.

In the case of associated electrical apparatus the symbol EEx ia or EEx ib (or ia or ib if EEx is already marked) shall be enclosed in square brackets.

Where external circuits have to be connected to electrical apparatus and these circuits affect the intrinsic safety of the electrical apparatus, the limiting characteristics of such circuits including cables shall always be specified in the certification documents and, if practicable, marked on the electrical apparatus (see examples).

If tests with the spark test apparatus are carried out with a disc other than cadmium, or if the curves in Figure A.1.2 or Figure A.2.2 or the Sn curves in Figure A.3.1 or Figure A.3.2 of Annex A are used, the electrical apparatus shall be marked with the symbol X as prescribed in European Standard EN 50014 “General requirements”.

10.2 Marking of diode safety barriers. In addition to the marking prescribed in 10.1 the maximum voltage (in volts) which may be safely applied to the non-intrinsically safe connection facilities of a barrier shall be marked on the barrier. The symbol to be used in this case is U_M . The maximum output voltage of the barrier (in volts) shall also be marked; the symbol to be used in this case is U_z .

Example: $\frac{250 U_M}{30 U_z}$ or $250 U_M - 30 U_z$

10.3 Marking of connection facilities. Connection facilities, terminal boxes and plugs and sockets of intrinsically safe electrical apparatus and associated electrical apparatus shall be clearly marked and shall be clearly identifiable. Where a colour is used for this purpose, it shall be light blue.

10.4 Examples of marking

a) Self-contained intrinsically safe electrical apparatus

C. TOME LTD
PAGING RECEIVER TYPE 3
EEx ia IIC T4
BASEEFA no. 78.023

b) Intrinsically safe electrical apparatus designed to be connected to other apparatus

M. HULOT
TRANSDUCTEUR TYPE 12
EEx ib I/IIB T5
CERCHAR no. 79.012X
 $L_{\text{éq}} = 0.12 \text{ H}$ $C_{\text{éq}} = 1\,200 \text{ pF}$
 $U_{\text{max}}: 28 \text{ V}$

c) Associated electrical apparatus

J. SCHMIDT A.G.
STROMVERSORGUNG TYP 4
[EEx ib] I
B V S no. 77.026X
 $C_{\text{ext}} < 0.2 \mu\text{F}$ $L_{\text{ext}} < 2 \text{ mH}$
 $U_{\text{max}}: 28 \text{ V}$ $I_k: 183 \text{ mA}$

d) Associated electrical apparatus protected by an EEx d enclosure

PIZZA ELECT. SpA
CONTROL UNIT Type 310
EEx d [ia] IIB T6
C E S I no. 77.199X
 $C_{\text{ext}} < 0.5 \mu\text{F}$ $L_{\text{ext}} < 1 \text{ mH}$
 $U_{\text{max}}: 36 \text{ V}$ $I_{\text{cc}}: 0.3 \text{ A}$

Annex A Minimum igniting curves

(Integral part of the standard)

