

AS/NZS IEC 60079.11:2024
IEC 60079-11:2023



Australian/New Zealand Standard™

Explosive atmospheres

Part 11: Equipment protection by intrinsic safety "i"



AS/NZS IEC 60079.11:2024

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Part 11: Equipment protection by intrinsic safety "i"

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Preface

This Standard was prepared by the Joint Standards Australia/ Standards New Zealand Committee EL-014, Equipment for Explosive Atmospheres to supersede AS/NZS 60079.11:2011, *Explosive atmospheres, Part 11: Equipment protection by intrinsic safety 'i'*.

The objective of this document is to specify the construction and testing of intrinsically safe apparatus intended for use in explosive atmospheres, and for associated apparatus which is intended for connection to intrinsically safe circuits which enter such atmospheres.

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

This document applies to sensors connected to intrinsically safe circuits but does not apply to the protection of catalytic elements for Group IIC or Group IIB + H2.

This document does not apply to Ex Equipment cable glands.

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

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Foreword

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IEC 60079-11 has been prepared by subcommittee 31G: Intrinsically safe apparatus, of IEC technical committee 31: Equipment for explosive atmospheres. It is an International Standard.

This seventh edition cancels and replaces the sixth edition published in 2011. This edition constitutes a technical revision.

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

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
A significant number of editorial changes including re-structuring of sections. These are too numerous to list in this table.	All	X		
Protection of catalytic elements for Group IIC or Group IIB + H ₂ excluded from the scope of the standard.	1 7.14.2			C2
Extension, with requirements, of ambient pressure down to 60 kPa.	1 6.5.6.1		B1	
Modification to Table 1 showing Clause 14 of IEC 60079-0 as 'Applies'. This does not affect the technical requirements.	1	X		
Definitions removed as they are now in IEC 60079-0. (References are from Ed.6) 3.2 coating 3.3 conformal coating 3.7.1 countable fault 3.7.3 non-countable fault 3.18 recurring peak voltage 3.20 encapsulation 3.21 casting 3.23 galvanic isolation	3	X		
Definitions removed as they are no longer considered necessary. (References are from Ed.6) 3.7.2 fault 3.10.3 Infallible separation	3	X		
Diode safety barriers no longer refers to devices that provide galvanic isolation.	3.1.7 7.7.5		X	
Intrinsic safety parameters and U_m can have brief transients above the stated values, and these do not need to be taken into account.	3.1.12 7.7.3	X		
New definition – spark test apparatus.	3.1.14	X		
New definition – electrochemical capacitor.	3.1.15		X	
New definition – transient rating.	3.1.16.1		X	
New definition – transient energy (previously let-through energy).	3.1.16.2	X		
New definition – non-hazardous area accessory.	3.1.17	X		
Clarification that it is not a requirement of this standard that conformance to industrial standards be verified.	5.1	X		
Clarification of conditions for the assessment added.	5.2.1	X		

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Clarification relating to the application of service temperatures.	5.2.1 g)			C1
Statements that Level of Protection "ia" and "ib" requirements are always sufficient for Level of Protection "ic".	5.2.2		X	
For Level of Protection "ic", faults are only considered for spark ignition assessment and the determination of U_o , I_o , L_i , C_i and L_i/R_i . A short circuit fault, and subsequent component faults arising, are now termed non-countable faults.	5.2.4 6.5.4.3 6.5.4.4 6.5.4.5			C3
For Level of Protection "ic", the types of components on which intrinsic safety depends are limited.	5.2.4		X	
Clarification of the requirements for non-shock hazard equipment or systems (for example SELV / PELV) for declaration of U_m .	5.2.5 12.1 c)	A1		
Clarification of where spark ignition assessment should and should not be applied.	5.3.1	X		
Clarification that spark ignition assessment may be performed on a representative circuit.	5.3.1 9.1.1	X		
Spark ignition assessment at normal ambient is suitable for service temperatures between $-60\text{ }^{\circ}\text{C}$ and $100\text{ }^{\circ}\text{C}$.	5.3.1		X	
Spark ignition testing of mains apparatus is at U_m rather than 110 % of the mains nominal voltage.	5.3.4.2 d)	X		
Annex G added as option for spark ignition assessment.	5.3.4.1 5.3.4.2 9.2.6 c) Annex G		X	
Clarification of the requirements for circuits with controlled semiconductor limitation, including need to consider both steady state and transient spark ignition compliance for circuits with controlled semiconductor limitation.	5.3.6 Annex D			C4
The exclusion of the IEC 60079-0 10 % safety margin on voltage for thermal ignition assessment extended to Groups I and II.	5.4.1		X	
The 1,3 W limit for T4 for tracks on a printed circuit board now only applies to $40\text{ }^{\circ}\text{C}$ ambient.	5.4.1			C5
The 5K and 10K margin required for temperature tests from IEC 60079-0 now apply for Level of Protection "ic".	5.4.2			C6
Corrected the formula for thermal assessment of wires.	5.4.3			C7
Clarified that only circuit board tracks exposed to the explosive atmosphere require temperature classification.	5.4.4	X		

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Added a note identifying examples of available data for determining temperature rise in PCB tracks (From IPC-2221 and IPC-2152).	5.4.4	X		
Clarified which dimensions can be reduced by manufacturer's tolerance (track width, board thickness, and conductor thickness).	5.4.4	X		
Clarified the use of Table 4 by introducing reduction factors for board thickness, number of layers, copper thickness, track under component, and ambient temperature.	5.4.4		X	
Added allowance for linear interpolation of allowed current, track width, track thickness, ambient temperature, and board thickness.	5.4.4		X	
Extrapolation of Table 4 is prohibited.	5.4.4			C1
Reduced the default board thickness for application of Table 4 from 1,6 mm to 1,55 mm to reflect industry standard.	5.4.4		X	
Clarified that the track under component reduction factor only applies if the portion of the track underneath the component is greater than 10 mm.	5.4.4		X	
Use of the 1,3 W limit for thermal ignition compliance for Group III extended to include Group I.	5.4.5		X	
Board thickness, copper thickness and ambient temperature factors extended in use of Table 4 .	5.4.4		X	
Enclosure requirement for Groups IIIA and IIIB aligned with Group I and Group II.	6.2.1		X	
Clarification that the IEC 60079-0 enclosure requirements apply for Group IIIC equipment with separations according to Table 7 (Ed 6 Table 5) that are reliant on an enclosure providing IP5X.	6.2.4 a)1)			C1
Requirement for a Specific Condition of Use added when use of reduced separations is reliant on an enclosure providing IP54.	6.2.5.1			C8
Plugs and sockets can comply with reduced separation requirements.	6.3.3		X	
Use of an enclosure to protect battery charging connections from spark ignition (Ed.6 clause 7.4.9) extended to include all non-hazardous area connection facilities.	6.3.5.2		X	
It is no longer necessary to define U_m for the connection from non-hazardous area connection facilities to accessories listed in the certificate provided the accessory is suitably marked and listed in the instructions.	6.3.5.3 11.1.5 12.1 j)		X	
It is no longer necessary to assess a non-hazardous area accessory in accordance with this standard.	6.3.5.3		X	

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Clarification that charging of cells and batteries in the non-hazardous area has to be within the limits specified by their manufacturer, and IEC 60079-0.	6.3.5.3	X		
Conductors, connectors and PCB tracks have to be suitably rated for their failure to be a countable fault.	6.4.1			C9
It is now a stated requirement that circuits remain intrinsically safe after disconnection of a connector.	6.4.1			C1
It is now a requirement that infallible connections remain capable of carrying the current following considered fault disconnections.	6.4.2.2 6.4.2.3			C10
Infallible PCB connection achieved with two 1 mm wide tracks now have copper thickness requirements.	6.4.2.4			C11
The options for infallible PCB connections have been extended.	6.4.2.4		B2	
Clarification that connections complying with IEC 60079-7 Level of Protection "eb" can be considered infallible.	6.4.2.5	X		
Clarification that insulation of component packaging cannot be relied upon for separation of conductive parts unless it is specified by the component manufacturer, except for shorts to its solder pads where they are similar to the recommendations of the component manufacturer.	6.5.1	X		
Alternate spacing requirements from the previous edition Annex F have been transferred to the main body of this document.		A2		
Specific Condition of Use only required for Overvoltage Category (OVC) I/II when using Table 8 – Reduced separations.	6.5.3.2		X	
Dielectric strength requirements have been clarified in Table 8 – Reduced separations.	6.5.3.2			C12
Specific Condition of Use required when OVC II/I is required for mains apparatus when using Table 9 – Reduced separations for Level of Protection "ic".	6.5.3.3			C13
Table 8 – Reduced separations is derived from Ed.6 Table F.1 but with additional requirements.	6.5.3.2		X	
Routine tests when using Table 8 – Reduced separations no longer have to be performed at the most onerous ambient condition.	6.5.3.2		X	
Table 9 – Reduced separations for Level of Protection "ic" is derived from Ed.6 Table F.2 but with additional requirements.	6.5.3.3		X	
Additional options for infallible separations when exposing connection facilities.	6.5.4.2		X	

		Type		
Explanation of the significance of changes	Clause	Minor and editorial changes	Extension	Major technical changes
Separations tables clarify that the voltages do not need to include non-repetitive transients.	Table 7 Table 8 Table 9	X		
Determination of type and routine testing required when using reduced separations tables.	Table 8 6.5.6.2 6.5.6.3 6.5.6.5 9.7			C14
Additional separation distance options.	Table 8 Table 9		X	
Dielectric strength test is no longer required for all separations through casting compound and solid insulation.	6.5.6.2 6.5.6.3		X	
When Comparative Tracking Index (CTI) Is unknown, a CTI of 100 may be assumed, and some materials are identified as non-tracking.	6.5.6.4		X	
Extended and clarified requirements for assessing creepage distances.	6.5.6.4		X	
Two coats of conformal coating no longer required when spraying.	6.5.6.5		X	
Consideration of composite separations extended to reduced distances tables.	6.5.7		X	
Metal parts used for separation no longer have to be earthed.	6.5.9		X	
Where metal parts connected to the frame or earth are used to separate two circuits, a Specific Condition of Use is now required.	6.5.9.1			C15
Clarification that separation by metal parts requires infallible connection.	6.5.9.1			C1
Relaxation of requirements for non-metallic insulating partitions for Level of Protection "ic".	6.5.10		X	
Added requirements for insulation between internal wiring of separate intrinsically safe circuits.	6.5.11.3		X	
Encapsulation requirements have been separated and extended according to the purpose of the encapsulation.	6.6		X	
Routine verification of encapsulation added.	6.6.1 10.4			C16
The specified COT for encapsulation shall not be exceeded in normal operation. Tighter requirements for damage to compound for temperature greater than COT.	6.6.1 a)			C17
Free space within encapsulation other than within components is now permitted.	6.6.1 6.6.7		X	

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Requirements for specification of coating, encapsulation and moulding materials.	6.7			C18
Components used to protect against polarity reversal have to be rated to 7.1 .	6.8			C1
It is now stated that there are circumstances where 2/3 rd rating for all three of voltage, current and power are not applicable for Levels of Protection "ia" and "ib".	7.1	X		
Power rating for Level of Protection "ic" does not require a 1,5 safety factor following the application of faults.	7.1		X	
Components for Level of Protection "ic" are considered to fail if they are not within their manufacturer's rating following the application of faults.	7.2			C19
Clarification of the application of manufacturing variations added.	7.3	X		
Resistors of types not listed (film, wire wound and printed) cannot now be considered to fail as a countable fault, nor to limit their own temperature.	7.4.2			C20
Clarified that the voltage rating to which the safety factor is applied is that of the resistor series, and not that based on the resistance.	7.4.2	X		
Clarification of the power rating of resistors in series with supercapacitors.	7.4.2	X		
Cold resistance of a fuse, filament of a bulb or infra-red source is assessed at the service temperature rather than the ambient temperature.	7.4.2			C21
The filament of an infra-red sensor can be used as a resistor for limitation.	7.4.2		X	
Clarification that self-heating of capacitors need not be considered.	7.5.1		X	
An arrangement of two series blocking capacitors need have only half of the infallible separation across each when using Table 7 and Table 9 (this was already permitted for Table 8).	7.5.3		X	
Clarification of the failure modes for inductors and transformers.	7.6.1 7.8.1	X		
References to IEC 60317 updated.	7.6.3	X		
Added requirements and tests for common mode chokes which provides allowances to consider only the leakage inductance of common mode chokes, or the inductance of only one coil.	7.6.5 9.15		X	
Clarification that assessment of semiconductors cannot be based on failure rates.	7.7.1			C1

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
An enhanced voltage generated by an integrated circuit does not need to be considered as being present on other connected pins.	7.7.1 c)		X	
Added an allowance for low complexity semiconductors to avoid being considered to fail so as to dissipate maximum power.	7.7.1.d)2)		X	
Transient rating of semiconductors only applied to transients caused by current limitation.	7.7.3		X	
Clarification that a safety factor of 1,0 is required when assessing the transient power rating of a semiconductor on which intrinsic safety depends.	7.7.3	X		
For Level of Protection "ic", transient rating of semiconductors is only necessary for diode safety barriers.	7.7.3		X	
Where two diodes are used in a safety shunt for Level of Protection "ia", the failure of only a single diode has been extended to the failure of a single shunt path. This means that the tracking from the diode to reference voltages (for example, ground) no longer have to be infallible.	7.7.6		X	
Controlled semiconductor current limitation is permitted for Level of Protection "ia".	7.7.7		X	
Clarification of the requirements for programmable components.	7.7.8			C1
Statement that transformers need not be considered to increase the voltage or current beyond that defined by their turns ratio.	7.8.1	X		
Table 17 extended with a 10 A column.	7.8.3		X	
Foil / screen thickness for 10 A added.	7.8.3		X	
Clarification that the requirement for mains transformers includes any transformer that is not galvanically isolated from the mains.	7.8.4.1			C1
Reduced requirements for transformers that are galvanically isolated from the mains.	7.8.4.2		X	
Clarification of requirements for transformers for Level of Protection "ic".	7.8.5 9.17.4	X		
Requirements for transformers for Level of Protection "ic" added.	7.8.5			C22
Clarification of the rating requirements for relays.	7.9.2	X		
Countable fault separation between the coil and contacts of a relay is no longer permitted.	7.9.2 a)			C23
Addition of option for relays depending on reduced separation distances internally to comply with IEC 61810-1.	7.9.2		X	
Relays in Level of Protection "ic" need only comply with the relevant industrial standards.	7.9.2		X	

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Clarified that IEC 60079-28 does not apply to self-contained optical isolators.	7.10.1	X		
Addition of options for non-optical signal isolators.	7.10.2		X	
Clarified that a single fuse is sufficient.	7.11	X		
Clarification that the cold resistance of a fuse cannot be used to limit the breaking current.	7.11			C1
A fuse in Level of Protection "ic" shall be considered an ignition risk if its opening is an expected occurrence.	7.11			C24
Clarification that the breaking capacity of fuses connected to U_m may be less than 1 500 A provided that the maximum prospective current is stated in the instructions.	7.11 12.1 j)			C25
Cells which may explode no longer require a statement from the manufacturer of the cell that they are safe for use in any particular apparatus.	7.12.1		X	
Clarification that temperature rise and electrolyte leakage should be considered for cells.	7.12.1			C1
Clarification that short circuit of a single cell is considered a non-countable fault.	7.12.2			C1
Demonstration of the concentration of hydrogen can come from the manufacturer, rather than the manufacturer of the battery.	7.12.4		X	
Containers for sealed cells and batteries no longer need the pressure test of 9.14.4 .	7.12.4		X	
Clarification of conditions for determining cell voltages	7.12.5	X		
Clarified that the requirements only apply to replaceable batteries.	7.12.8	X		
Crystal oscillators are excluded from the requirements for piezoelectric devices, and there are extended requirements for Level of Protection "ic".	7.13		X	
Clarified that thermal assessment of catalytic sensors shall take into account heating due to the catalytic reaction.	7.14.2			C1
Clarification that supercapacitors shall be treated as batteries with a limited capacity but without the ability to limit their own voltage.	7.15 9.14			C26
Requirements and tests for thermal devices added, including PTCs.	7.16 9.12			C27
Clarification that mechanical switches do not require thermal ignition assessment.	7.17	X		
Clarification that the protective diodes in diode safety barriers shall be protected by a fuse or resistor(s) and not controlled semiconductor limitation.	8.1.1	X		

Explanation of the significance of changes	Clause	Type		
		Minor and editorial changes	Extension	Major technical changes
Additional options for earth facilities for diode safety barriers.	8.1.2.2		X	
Requirement for 110 % of the mains supply voltage when applying the spark test apparatus removed as the conditions for test are specified in 5.2 .	9.1.1		X	
Clarified that all circuits (not just capacitive) need to have time to recover where applicable during spark testing.	9.1.2	X		
Added allowance for slowing the spark test apparatus down when removing wires is not sufficient to allow rest of the circuit under test.	9.1.2		X	
Clarified that the effect of temperature on an inductor's resistance shall be taken into account during spark testing.	9.1.2			C1
Clarified that the sensitivity of the spark test apparatus may be checked if there is an unexpected failure.	9.1.2	X		
Minimum ignition current for calibration of the spark test apparatus added.	9.1.3	X		
Added formula option for reducing effective capacitance with a resistor.	9.2.3.3		X	
Clarification that consideration of the combination of inductance and capacitance is required internal to equipment and not just at connection facilities.	9.2.6	X		
An assessment that demonstrates that the safety factor is maintained with a combination of both inductance and capacitance is allowed.	9.2.6 b)		X	
Where parameters are specified for combined lumped inductance and capacitance, that shall be stated in the certificate or documentation.	9.2.6	X		
30 N test for casting compound and partitions are not applicable for Level of Protection "ic".	9.4.1 9.4.3		X	
Test temperature for immersion in water for encapsulated fuses has been lowered by 2 °C for compatibility with other testing.	9.4.2	X		
Parameters for loosely specified components shall be determined taking into account the service temperature, not just the ambient temperature.	9.13	X		
Clarification and modification of the tests for optical isolators.	9.10		X	
Clarified that tests on piezoelectric devices need be performed on only a single sample, unless that sample is damaged during the testing.	9.11	X		
Clarified that primary cells shall be unused and limiting devices shall be removed for the electrolyte leakage test.	9.14.1	X		

		Type		
Explanation of the significance of changes	Clause	Minor and editorial changes	Extension	Major technical changes
Clarified that the current shall be continuous when discharging during the tests.	9.14.1			C1
Cells that have essential features that limit their current may be used for Level of Protection "ia".	9.14.1		X	
Cells that explode or catch fire during short circuit test shall not be used for Levels of Protection "ia" and "ib".	9.14.1	X		
Electrolyte leakage and surface temperature test requirements for cells and batteries modified to cover the number of samples tested, the test temperature, and testing with dust layers.	9.14.1			C28
Added option to conduct short circuit until discharge testing for Level of Protection "ic" to establish compliance with the electrolyte leakage requirement.	9.14.2 a)		X	
Added alternative assessment of damage to encapsulation from leaked electrolyte.	9.14.2		X	
Spark ignition of batteries may be carried out following current limitation where separation is maintained.	9.14.3.2		X	
Requirement added to consider the spark ignition risk of single lithium cells of less than 4,5 V with high short circuit current.	9.14.3.2			C29
For single cells, it is sufficient to measure the temperature in the middle of the cell rather than having to locate the highest temperature point.	9.14.3.3		X	
For thermal ignition assessment of cells and batteries with Level of Protection "ib", added an alternative test for lithium-ion rechargeable cells where it is not possible to obtain samples with current limiting devices disabled. There is an assumption that these cells will leak electrolyte so 7.12.3 applies.	9.14.3.3 b) 9.14.2		X	
Where limiting devices are removed from a cell for testing, it is no longer necessary to also test with 10 samples with the limiting devices still in place.	9.14.3.3		X	
Only a single sample need be tested for thermal ignition compliance testing of cells or batteries for Level of Protection "ic".	9.14.3.3 c)		X	
Transient test for diode safety barriers and safety shunts has been extended to include controlled semiconductor current limitation.	9.16		X	
Clarify that transformer dielectric strength test is a test at room temperature.	9.17.1	X		
Reduced testing requirements for transformers that are galvanically isolated from the mains.	9.17.3		X	

		Type		
Explanation of the significance of changes	Clause	Minor and editorial changes	Extension	Major technical changes
Transformer windings requiring galvanic separation between different intrinsically safe circuits are to be tested for a dielectric strength of 2U if that is greater than 500 V.	10.3.1			C30
Transformers for Level of Protection "ic" shall be routine tested where there is no applicable industrial standard, or the applicable industrial standard does not specify a routine test.	10.3.2			C31
Marking of IP rating no longer required as this is now a Specific Condition of Use.	11		X	
Flowchart for testing of enclosures added.	Annex I	X		
List of voltage limiting techniques has been deleted.	former 8.7.3	A3		
Requirements for handlights and caplights removed as these are covered elsewhere (including in other standards).	former 9.3	X		

NOTE The technical changes referred to include the significance of technical changes in the revised IEC Standard, but they do not form an exhaustive list of all modifications from the previous version.

Explanations:

A) Definitions

Minor and editorial changes

clarification
decrease of technical requirements
minor technical change
editorial corrections

These are changes which modify requirements in an editorial or a minor technical way. They include changes of the wording to clarify technical requirements without any technical change, or a reduction in level of existing requirement.

Extension

addition of technical options

These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing requirements for equipment that was fully compliant with the previous standard. Therefore, these will not have to be considered for products in conformity with the preceding edition.

Major technical changes

addition of technical requirements
increase of technical requirements

These are changes to technical requirements (addition, increase of the level or removal) made in a way that a product in conformity with the preceding edition will not always be able to fulfil the requirements given in the later edition. These changes have to be considered for products in conformity with the preceding edition. For these changes additional information is provided in clause B) below.

NOTE These changes represent current technological knowledge. However, these changes should not normally have an influence on equipment already placed on the market.

B) Information about the background of Changes

- A1 U_m is to be applied across galvanic isolations.
- A2 The Annex for 'Alternative separation distances for assembled printed circuit boards and separation of components' in the previous edition is now incorporated in the main text and the alternate spacing tables are now [Table 8](#) and [Table 9](#).
- A3 Except for c) batteries for which there is no longer a suggestion that they can be used as voltage limiting shunt devices. Nonetheless, there is no intent to change their use as such.
- B1 Apparatus may be used at lower atmospheric pressure than the default 80 kPa specified in IEC 60079-0 with additional requirements such as an increase in clearance for associated apparatus operated at less than 80 kPa.
- B2 The values used were based on those in IPC-6012B and tolerances have been taken into account.
- C1 It is recognized that the clarified requirements were, in many cases, already applied. The change is to ensure that they are uniformly and consistently applied.
- C2 Catalytic sensors have been demonstrated to auto-ignite hydrogen without electrical stimulus so are not suitable for protection by intrinsic safety.
- C3 Failure of separations and subsequent failure of components are considered non-countable faults for "ic". This is expected to be a change in terminology only but is highlighted here as it could change the assessment methodology in some instances.
- C4 The steady state maximum voltage and current presents a different spark ignition risk than a transient. A transient is where either of these (voltage or current) is exceeded. Therefore, steady states and transients need to be considered separately. The Annex on transients has been revised.
- C5 Modified to align with assessment for wires.
- C6 Since thermal assessment for Level of Protection "ic" is substantively under normal operation, the margin is considered a required safety factor.
- C7 The formula used for calculating the temperature rise of wiring has been corrected.
- C8 Where reduced separation distances rely on an enclosure providing an ingress protection of IP54, and cable glands, thread adapters and blanking elements are necessary to complete the enclosure to maintain the Ingress Protection (IP) rating these also need to comply with IEC 60079-0.
- C9 Conductors, connectors and PCB tracks have to be suitably rated for their failure to be a countable fault.
- C10 It is now a requirement that infallible connections remain capable of carrying the current following considered fault disconnections.
- C11 Infallible PCB connection achieved with two 1 mm wide tracks now have copper thickness requirements.
- C12 The safety of reduced separations relies on a suitable dielectric strength for the insulating materials, and these have been added to [Table 8](#).

- C13 A Specific Condition of Use is required when Over Voltage Category II/I is required for mains apparatus when using [Table 9](#) – Reduced separations for Level of Protection "ic".
- C14 The previous edition made references to the tests in IEC 60664-1 and IEC 60664-3, however, it did not state which tests applied. This edition clarifies which tests apply by including them in the text.
- C15 This is to be compatible with the Specific Condition of Use already required where insulation between an intrinsically safe circuit and the frame or earth does not meet the dielectric strength requirements.
- C16 A routine inspection requirement was added for encapsulated parts to ensure that the application of the encapsulant is acceptable during manufacture.
- C17 The Continuous Operating Temperature requirements are a modification of those specified in IEC 60079-0. When temperatures higher than the COT are possible, there must be no damage internally or externally, whereas for Ed.6 the requirement was no visible damage.
- C18 The specifications required for coating, encapsulation and moulding are a modification of those detailed in IEC 60079-0.
- C19 Ed.6 did not state how to consider failure of components where the application of failure of separation resulted in them being operated outside of their manufacturer's specification. This is considered necessary, but for spark ignition only.
- C20 This is a consequence of the re-organisation of the requirements for components.
- C21 The cold resistance was previously permitted to be measured at the minimum ambient temperature.
- C22 It was recognised that when the requirements for Ex nL were transferred into IEC 60079-11 as Ex ic not all components were addressed. This meant that an Ex ia transformer construction was required for Ex ic equipment.
- C23 Countable fault separation between the coil and contacts of a relay is no longer permitted.
- C24 A fuse in Level of Protection "ic" shall be considered an ignition risk if its opening is an expected occurrence.
- C25 Fuses connected to the mains supply are permitted to have a breaking capacity of less than 1 500 A. However, it is necessary that users and installers are made aware when this is the case and therefore it is a requirement to include the maximum prospective current in the instructions.
- C26 Requirements for supercapacitors added.
- C27 Requirements for the use of thermal devices (PTCs etc.) have been added.
- C28 Electrolyte leakage, surface temperature test and test under dust requirements for cells, batteries and supercapacitors modified, increasing the number of samples tested and defining the temperature at which the tests are conducted.
- C29 Spark ignition has been demonstrated during short circuit of some lithium cells.
- C30 Routine tests for transformers with primary and secondary windings in an intrinsically safe circuit changed.

C31 Addition of a specific routine test for transformers used in Ex ic circuits.

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

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

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

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

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

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

A list of all parts of the IEC 60079 series, under the general title: *Explosive atmospheres*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

The contents of the corrigendum 1 (2023-06) have been included in this copy.

NOTES

Australian/New Zealand Standard

Explosive atmospheres

Part 11: Equipment protection by intrinsic safety "i"

1 Scope

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

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

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

This document applies to sensors connected to intrinsically safe circuits but does not apply to the protection of catalytic elements for Group IIC or Group IIB + H₂.

This document does not apply to Ex Equipment cable glands.

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

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

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

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

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

Table 1 — Applicability of specific clauses of IEC 60079-0

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
3	3	Terms and definitions	Applies	Applies	Applies
4	4	Equipment grouping	Applies	Applies	Applies
5	5	Temperatures			
5.1	5.1	Environmental influences	Applies	Applies	Applies

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
5.2	5.2	Service temperature	Applies	Applies	Applies
5.3	5.3	Maximum surface temperature	Applies	Applies	Excluded
6	6	Requirements for all electrical apparatus			
6.1	6.1	General	Applies	Applies	Applies
6.2	6.2	Mechanical strength	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
6.3	6.3	Opening times	Excluded	Excluded	Excluded
6.4	6.4	Circulating currents in enclosures (e.g. of large electric machines)	Excluded	Excluded	Excluded
6.5	6.5	Gasket retention	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
6.6	6.6	Electromagnetic and ultrasonic energy radiating equipment			
-	6.6.1	General	Applies	Applies	Excluded
6.6.1	6.6.2	Radio frequency sources	Applies	Applies	Excluded
6.6.3	6.6.3	Ultrasonic sources	Applies	Applies	Excluded
6.6.2	6.6.4	Lasers, luminaires and other non-divergent continuous wave optical sources	Modified	Modified	Excluded
7	7	Non-metallic enclosures and non-metallic parts of enclosures			
7.1	7.1	General	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
7.2	7.2	Thermal endurance	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
7.3	7.3	Resistance to ultraviolet light	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
7.4	7.4	Electrostatic charges on external non-metallic materials	Applies	Applies	Excluded
7.5	7.5	Attached external conductive parts	Applies	Applies	Excluded
8	8	Metallic enclosures and metallic parts of enclosures	Applies	Applies	Excluded
9	9	Fasteners	Excluded	Excluded	Excluded

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
10	10	Interlocking devices	Applies	Applies	Excluded
11	11	Bushings	Excluded	Excluded	Excluded
12	-	Materials used for cementing	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 are applied	Excluded except when 6.2.5.1 is applied
-	12	(Reserved for future use)	-	-	-
13	13	Ex Components	Applies	Applies	Applies
14	14	Connection facilities			
14.1	14.1	General	Applies	Applies	Applies
14.2	-	Termination compartment	Applies	Applies	Applies
14.3	14.2	Type of Protection	Applies	Applies	Modified
14.4	14.3	Creepage and clearance	Applies	Applies	Applies
15	15	Connection facilities for earthing or bonding conductors	Excluded	Excluded	Excluded
16	16	Entries into enclosures			
16.1	16.1	General	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.2	16.2	Identification of entries	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.3	16.3	Cable Glands	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.4	16.4	Blanking elements	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.5	16.5	Thread adapters	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.6	16.6	Temperature at branching point and entry point	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
16.7	16.7	Electrostatic charges of cable sheaths	Applies	Applies	Applies
17	17	Supplementary requirements for electric machines	Excluded	Excluded	Excluded
18	18	Supplementary requirements for switchgear	Excluded	Excluded	Excluded
19	-	Supplementary requirements for fuses	Excluded	Excluded	Excluded
-	19	Reserved for future use	-	-	-

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
20	20	Supplementary requirements for external plugs, socket outlets and connectors for field wiring connection	Excluded	Excluded	Excluded
21	21	Supplementary requirements for luminaires	Excluded	Excluded	Excluded
22	22	Supplementary requirements for caplights and handlights			
22.1	22.1	Group I caplights	Applies	Excluded	Excluded
22.2	22.2	Group II and Group III caplights and handlights	Excluded	Excluded	Excluded
23	23	Equipment incorporating cells and batteries			
23.1	23.1	General	Applies	Applies	Applies
23.2	23.2	Interconnection of cells to form batteries	Excluded	Excluded	Excluded
23.3	23.3	Cell types	Modified	Modified	Modified
23.4	23.4	Cells in a battery	Applies	Applies	Applies
23.5	23.5	Ratings of batteries	Applies	Applies	Applies
23.6	23.6	Interchangeability	Applies	Applies	Applies
23.7	23.7	Charging of primary batteries	Applies	Applies	Applies
23.8	23.8	Leakage	Applies	Applies	Applies
23.9	23.9	Connections	Applies	Applies	Applies
23.10	23.10	Orientation	Applies	Applies	Applies
23.11	23.11	Replacement of cells or batteries	Applies	Applies	Applies
23.12	23.12	Replaceable battery pack	Applies	Applies	Applies
24	24	Documentation	Applies	Applies	Applies
25	25	Compliance of prototype or sample with documents	Applies	Applies	Applies
26	26	Type tests			
26.1	26.1	General	Applies	Applies	Applies
26.2	26.2	Test configuration	Applies	Applies	Applies
26.3	26.3	Tests in explosive test mixtures	Applies	Applies	Applies
26.4	26.4	Tests of enclosures			
26.4.1	26.4.1	Order of tests	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
26.4.2	26.4.2	Resistance to impact	Excluded except see ^a	Excluded except see ^a	Excluded except see ^a
26.4.3	26.4.3	Drop test	Applies	Applies	Applies
26.4.4	26.4.4	Acceptance criteria	Applies	Applies	Applies
26.4.5	26.4.5	Degree of protection (IP) by enclosures	Applies	Applies	Applies
26.5	26.5	Thermal tests			
26.5.1	26.5.1	Temperature measurement			
26.5.1.1	26.5.1.1	General	Applies	Applies	Excluded
26.5.1.2	26.5.1.2	Service temperature	Applies	Applies	Applies
26.5.1.3	26.5.1.3	Maximum surface temperature	Modified	Modified	Excluded
26.5.2	26.5.2	Thermal shock test	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
26.5.3	26.5.3	Small component ignition test (Group I and Group II)	Applies	Excluded	Excluded
26.6	26.6	Torque test for bushings	Excluded	Excluded	Excluded
26.7	26.7	Non-metallic enclosures or non-metallic parts of enclosures	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
26.8	26.8	Thermal endurance to heat	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
26.9	26.9	Thermal endurance to cold	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
26.10	26.10	Resistance to UV light	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
26.11	26.11	Resistance to chemical agents for Group I equipment	Excluded except when 6.2.5.1 is applied	Excluded	Excluded
26.12	26.12	Earth continuity	Excluded	Excluded	Excluded
26.13	26.13	Surface resistance test of parts of enclosures of non-metallic materials	Applies	Applies	Excluded
26.14	26.14	Measurement of capacitance	Applies	Applies	Excluded
26.15	26.15	Verification of ratings of ventilating fans	Excluded	Excluded	Excluded
26.16	26.16	Alternative qualification of elastomeric sealing O-rings	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
NR	26.17	Transferred charge test	Applies	Excluded	Excluded
27	27	Routine tests	Applies	Applies	Applies
28	28	Manufacturer's responsibility	Applies ^b	Applies ^b	Applies
29	29	Marking			
29.1	29.1	Applicability	Applies	Applies	Applies
29.2	29.2	Location	Applies	Applies	Applies
29.3	29.3	General	Applies	Applies	Applies
29.4	29.4	Ex marking for explosive gas atmospheres	Applies	Excluded	Applies
29.5	29.5	Ex marking for explosive dust atmospheres	Excluded	Applies	Applies
29.6	29.6	Combined types (or levels) of protection	Applies	Applies	Applies
29.7	29.7	Multiple types of protection	Applies	Applies	Applies
29.8	29.8	Ga equipment using two independent Gb types (or levels) of protection	Applies	Excluded	Excluded
NR	29.9	Boundary wall	Applies	Applies	Excluded
29.9	29.10	Ex Components	Applies	Applies	Applies
29.10	29.11	Small Ex Equipment and small Ex Components	Applies	Applies	Applies
29.11	29.12	Extremely small equipment and extremely small Ex Components	Applies	Applies	Applies
29.12	29.13	Warning markings	Applies	Applies	Applies
29.13	-	Alternate marking of Equipment Protection Levels (EPLs)	Applies	Applies	Applies
29.13.1	-	Alternate marking of Type of Protection for explosive gas atmospheres	Applies	Excluded	Applies
29.13.2	-	Alternate marking of Type of Protection for explosive dust atmospheres	Excluded	Applies	Applies
29.14	29.14	Cells and batteries	Applies	Applies	Applies
29.15	29.15	Electrical machines operated with a converter	Excluded	Excluded	Excluded
29.16	29.16	Examples of marking	Examples only	Examples only	Examples only
30	30	Instructions			
30.1	30.1	General	Applies	Applies	Applies
30.2	30.2	Cells and batteries	Applies	Applies	Applies

Table 1 (continued)

Clause or subclause of IEC 60079-0			IEC 60079-0 clause application to IEC 60079-11		
			Intrinsically safe apparatus		Associated apparatus
Ed.6 (2011) (informative)	Ed.7 (2017) (informative)	Clause / Subclause title (normative)	Group I and Group II	Group III	
30.3	30.3	Electric machines	Excluded	Excluded	Excluded
30.4	30.4	Ventilating fans	Excluded	Excluded	Excluded
-	30.5	Cable Glands	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
Annex A	Annex A	Supplementary requirements for cable glands	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied	Excluded except when 6.2.5.1 is applied
Annex B	Annex B	Requirements for Ex Components	Applies	Applies	Applies
Annex C	Annex C	Example of rig for resistance to impact test	Informative Annex	Informative Annex	Informative Annex
Annex D	Annex D	Electric machines connected to converters	Informative Annex	Informative Annex	Informative Annex
Annex E	Annex E	Temperature evaluation of electric machines	Informative Annex	Informative Annex	Informative Annex
Annex F	Annex F	Guideline flowchart for tests of non-metallic enclosures or non-metallic parts of enclosures (26.4)	Informative Annex	Informative Annex	Informative Annex
-	Annex G	Guidance flowchart for tests of cable glands	Informative Annex	Informative Annex	Informative Annex
-	Annex H	Shaft voltages resulting in motor bearing or shaft brush sparking. Discharge energy calculation	Informative Annex	Informative Annex	Informative Annex

Applies – This Clause / Subclause of IEC 60079-0 is applied without change.

Excluded – This Clause / Subclause of IEC 60079-0 does not apply.

Modified – This Clause / Subclause of IEC 60079-0 is modified as detailed in this document.

NOTE 1 The applicable Clauses / Subclauses of IEC 60079-0 are identified by the Clause / Subclause title which is normative. This document was written against the specific requirements of IEC 60079-0:2017 (Ed.7). The Clause / Subclause numbers for the 7th and previous edition are shown for information only. This is to enable the general requirements of IEC 60079-0:2011 (Ed.6) to be used where necessary with this part of IEC 60079. Where there were no requirements in the 6th edition but there are for the 7th edition (indicated by NR against the 6th edition only), or where there is a conflict between requirements, the later edition requirements take precedence.

NOTE 2 A shaded row in the above table indicates that this is a Clause heading. In cases where the applicability is the same for all the subclauses the 'Applies' or 'Excluded' is listed in the heading row and the subclauses are not expanded. Where the application of the individual sub-clauses may be different, these are expanded in the above table and the applicability for each is listed.

^a Excluded except when [6.2.5.1](#) is applied, or as required by [9.4.1](#) or [9.11](#).

^b Excluded for simple apparatus. See [3.1.5](#) and [5.5](#).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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

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

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

IEC 60127 (all parts), *Miniature fuses*

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

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

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

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

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

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

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

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

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

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

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

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

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

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

UL 810A, *Standard for Electrochemical Capacitors*

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

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1.1

intrinsic safety "i"

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

3.1.2

intrinsically safe apparatus

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

3.1.3

associated apparatus

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

Note 1 to entry: Associated apparatus is either:

- a) additionally protected by a Type of Protection suitable for use in the appropriate explosive atmosphere, or
- b) not protected by a Type of Protection suitable for use in the appropriate explosive atmosphere and therefore is not to be used within an explosive atmosphere

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

3.1.4

intrinsically safe circuit

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

3.1.5

simple apparatus

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

3.1.6

control drawing

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

3.1.7

diode safety barrier

associated apparatus, which does not provide galvanic isolation, incorporating shunt diodes or diode chains (including Zener diodes) protected by fuses or resistors or a combination of these, manufactured as an individual apparatus rather than as part of a larger apparatus

3.1.8 fuse rating

I_n
nominal current rating of a fuse

3.1.9 FISCO Fieldbus Intrinsically Safe Concept

intrinsically safe system architecture which is bus-powered and designed in accordance with specific requirements

Note 1 to entry: The requirements are specified in IEC 61158-2, *Industrial communication networks – Fieldbus specifications – Part 2: Physical layer specification and service definition*.

3.1.9.1 infallible connection

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

Note 1 to entry: The specific conditions to be considered are specified in IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*.

3.1.10 internal wiring

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

3.1.11 live maintenance

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

3.1.12 intrinsic safety parameters

Note 1 to entry: Voltage, current and power at connection facilities may have brief transients above the specified parameter value, as permitted by IEC 60079-11.

Note 2 to entry: Apparatus can have multiple sets of intrinsic safety parameters.

3.1.12.1 U_i maximum input voltage

maximum (peak) voltage that can be applied to the intrinsically safe connection facilities of the apparatus without invalidating intrinsic safety

3.1.12.2 I_i maximum input current

maximum (peak) current for the intrinsically safe connection facilities of the apparatus, that can be taken from external circuits connected to the connection facilities without invalidating intrinsic safety

3.1.12.3 P_i maximum input power

maximum power for the intrinsically safe connection facilities of the apparatus, that can be taken from external circuits connected to the connection facilities without invalidating intrinsic safety

3.1.12.4 **C_i** **maximum internal capacitance**

maximum equivalent internal capacitance of the apparatus, which is considered as appearing at the intrinsically safe connection facilities of the apparatus

3.1.12.5 **L_i** **maximum internal inductance**

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

3.1.12.6 **L_i/R_i** **maximum internal inductance to resistance ratio**

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

3.1.12.7 **U_o** **maximum output voltage**

maximum (peak) voltage that can appear at the intrinsically safe connection facilities of the apparatus

3.1.12.8 **I_o** **maximum output current**

maximum (peak) current that can be taken from the intrinsically safe connection facilities of the apparatus

3.1.12.9 **P_o** **maximum output power**

maximum electrical power that can be taken from the intrinsically safe connection facilities of the apparatus

3.1.12.10 **C_o** **maximum external capacitance**

maximum capacitance that can be connected to the intrinsically safe connection facilities of the apparatus without invalidating intrinsic safety

3.1.12.11 **L_o** **maximum external inductance**

maximum inductance that can be connected to the intrinsically safe connection facilities of the apparatus without invalidating intrinsic safety

3.1.12.12 **L_o/R_o** **maximum external inductance to resistance ratio**

maximum value of the ratio of inductance to resistance which can be connected to the intrinsically safe connection facilities of the apparatus without invalidating intrinsic safety

3.1.12.13 **U_m** **maximum RMS AC or DC voltage**

maximum voltage that can be applied to the non-intrinsically safe connection facilities of associated apparatus, or to the connection facilities of intrinsically safe apparatus for use only in the non-hazardous area, without invalidating intrinsic safety

EXAMPLE Examples of connection facilities of intrinsically safe apparatus restricted to use in the non-hazardous area are battery charging contacts and data interfaces.

Note 1 to entry: The value of U_m can be different at different sets of connection facilities, and can be different for AC and DC voltages.

Note 2 to entry: There may be transients above the specified parameter.

3.1.13 moulding

process of placing an object in a tool with a shaping cavity and introducing plastic material around the inserted component under pressure to either partially or totally encapsulate the inserted component

Note 1 to entry: This process is also referred to as injection moulding, over-moulding or insert moulding.

3.1.14 spark test apparatus

apparatus used to verify experimentally that the electrical sparks of a circuit are incapable of igniting a specified explosive gas atmosphere

3.1.15 supercapacitor electrochemical capacitor

device that stores electrical energy using a double layer in an electrochemical cell

Note 1 to entry: The electrochemical capacitor is not to be confused with electrolytic capacitor.

[SOURCE: IEC 60050-114:2014, 114-03-03]

3.1.16 transients

3.1.16.1 transient rating

rating of a component related to transient effects

EXAMPLE An example is I^2t value or peak non-repetitive surge current.

3.1.16.2 transient energy

energy delivered by a circuit above the steady state condition

3.1.17 non-hazardous area accessory

(intrinsic safety) electrical equipment to which intrinsically safe apparatus is temporarily connected by the end user, only while the intrinsically safe apparatus is in a non-hazardous area

EXAMPLE Examples are battery chargers and data readers.

3.1.18 controlled semiconductor

semiconductor component with an output that can be switched or adjusted using a separate electrical input

EXAMPLE Transistor, thyristor, voltage or current regulator.

Note 1 to entry: The inputs and outputs referred to above may form part of an integrated circuit.

3.2 Abbreviated terms

A list of abbreviated terms is given in [Table 2](#).

Table 2 — List of abbreviated terms used

Abbreviation	Full expression	Additional information
COT	continuous operating temperature	
CTI	comparative tracking index	Measured in accordance with IEC 60112
DUT	device under test	
ES1	Electrical energy source class 1	As defined in IEC 62368-1
FISCO	fieldbus intrinsically safe concept	See 3.1.9
OVC	overvoltage category	Defined in IEC 60664-1
PCB	printed circuit board	
PCBA	printed circuit board assembly	
PELV	protective extra-low voltage	For example, compliance with IEC 60364-4-41
PDV	partial discharge voltage	
PPTC	polymeric positive temperature coefficient	
PTC	positive temperature coefficient	Includes PPTC
SELV	safety extra-low voltage	For example, compliance with IEC 60364-4-41

4 Equipment grouping, classification and Levels of Protection of apparatus

Intrinsically safe apparatus and intrinsically safe circuits of associated apparatus shall be grouped in accordance with the equipment grouping requirements of IEC 60079-0.

Intrinsically safe apparatus shall have a maximum surface temperature or temperature class assigned in accordance with the requirements of IEC 60079-0. Temperature classification does not apply to associated apparatus.

NOTE Equipment containing associated apparatus protected by another Type of Protection will be assigned temperature class and equipment group according to the requirements of that Type of Protection. The equipment group for this equipment can be different to the group for intrinsic safety, for example equipment marked Ex db [ia IIC Ga] IIB T4 Gb.

Intrinsically safe apparatus and intrinsically safe circuits of associated apparatus shall be assigned one or more of the following Levels of Protection:

- Level of Protection “ia” (for EPL Ma, Ga, Da);
- Level of Protection “ib” (for EPL Mb, Gb, Db); or
- Level of Protection “ic” (for EPL Gc, Dc).

The requirements of this document apply to all Levels of Protection unless otherwise stated.

Apparatus may be specified with more than one Level of Protection, equipment group, or temperature class, and may have different intrinsic safety parameters for these varied cases.

5 Ignition compliance requirements

5.1 General

Compliance with this document requires two basic criteria:

- 1) intrinsically safe circuits shall meet the spark ignition requirements of [5.3](#); and
- 2) intrinsically safe apparatus shall meet the thermal ignition requirements of [5.4](#).

These shall be assessed under the conditions specified in [5.2](#) for the applicable Level of Protection, equipment group and, for intrinsically safe apparatus only, maximum surface temperature.

Fulfilment of these requirements is achieved by following this document, including consideration of:

- separation between conductive parts in accordance with [6.5](#);
- external connection facilities in accordance with [6.3](#) and internal connections in accordance with [6.4](#); and
- rating of components in accordance with [Clause 7](#).

Intrinsic safety parameters, U_m and, if required by [5.2.5](#), the maximum rated voltage for apparatus, may be assigned for each of the connection facilities.

NOTE IEC 60079-14 specifies the types of circuits or power supplies which are suitable for associated apparatus with a U_m of less than 250 V.

Where instructions for live maintenance procedures are specified by the manufacturer, the effects of this live maintenance shall not invalidate intrinsic safety. (See [12.1 d](#)).

Except for [9.6 a](#)), where it is stated that industrial standards are sufficient to meet the requirements of this document, it is not a requirement of this document that compliance with those industrial standards be verified.

5.2 Conditions for assessment

5.2.1 General

Intrinsically safe circuits shall not be capable of causing ignition under the most onerous conditions, except where permitted elsewhere in this document. This shall include, but is not limited to, the following:

- a) under the circumstances specified in [5.2.2](#), [5.2.3](#) or [5.2.4](#) as applicable for the Level of Protection;
- b) with any voltage up to U_m applied to non-intrinsically safe connection facilities, except as modified by [5.2.5](#);
- c) with any voltage up to U_i , current up to I_i or power up to P_i , as applicable, applied to intrinsically safe connection facilities;
- d) with any value up to the maximum capacitance as defined by C_o , as applicable, connected to the intrinsically safe connection facilities;
- e) with any value up to either the maximum inductance, as defined by L_o , or inductance to resistance ratio, as defined by L_o/R_o , as applicable, connected to the intrinsically safe connection facilities;
- f) with the connection of the most onerous load to any intrinsically safe connection facilities of the apparatus, including opening, shorting and earthing;
- g) at the most onerous temperature within the specified service temperature range for the applicable parts of the apparatus. For rating of components according to [Clause 7](#), and thermal ignition compliance for Levels of Protection "ia" and "ib", the effects of mounting conditions of the component and the service temperature local to the component shall be taken into account. Heating from other components from related faults might need to be considered.

EXAMPLES:

— Heating from closely located series or parallel components that carry or share the same fault current, normally need to be considered.

— Heating above service temperature from independent faults in other parts of the apparatus do not normally need to be considered.

NOTE Rating of a component is assessed without faults applied to the component, whereas its thermal ignition compliance is assessed with the most onerous faults according to [Clause 7](#) applied to the component;

and

- h) with the most onerous values of any relevant parameters applied within the manufacturing tolerances of the apparatus (see [7.3](#)).

Where a fault can lead to a subsequent fault or faults, then the primary and subsequent faults shall be considered to be a single fault. Within a single fault scenario, all countable and non-countable faults shall be considered static. For example, once a short circuit component fault is applied, this failure mode shall be maintained throughout the entire fault scenario.

For determination of the maximum surface temperature, a safety factor of 1,0 shall be applied to voltage and power.

5.2.2 Level of Protection "ia"

Intrinsically safe circuits in Level of Protection "ia" shall be assessed in each of the following circumstances:

- a) under the most onerous condition with no faults applied;
- b) with the application of those non-countable faults which result in the most onerous condition;
- c) with the application of one countable fault plus those non-countable faults which result in the most onerous condition; and
- d) with the application of two countable faults plus those non-countable faults which result in the most onerous condition.

The faults applied can differ in each of the above circumstances.

In assessing the circuits for spark ignition, the following safety factors shall be applied in accordance with [5.3.4](#):

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

If only one countable fault can occur, the requirements of d) need not be considered.

If no countable fault can occur, the requirements of c) and d) need not be considered.

Designs which conform to the requirements for Level of Protection "ia" are also suitable for Levels of Protection "ib" and "ic".

5.2.3 Level of Protection "ib"

Intrinsically safe circuits in Level of Protection "ib" shall be assessed in each of the following circumstances:

- a) under the most onerous condition with no faults applied;
- b) with the application of those non-countable faults which result in the most onerous condition; and
- c) with the application of one countable fault plus the application of those non-countable faults which result in the most onerous condition.

The faults applied can differ in each of the above circumstances.

In assessing the circuits for spark ignition, a safety factor of 1,5 shall be applied in accordance with [5.3.4](#).

If no countable fault can occur, the requirements of c) need not be considered.

Designs which conform to the requirements for Level of Protection "ib" are suitable for Level of Protection "ic".

5.2.4 Level of Protection "ic"

Intrinsically safe circuits in Level of Protection "ic" shall be assessed in each of the following circumstances:

- a) under the most onerous condition with no faults applied; and
- b) for spark ignition compliance in accordance with [5.3](#) and in the determination of U_o , I_o , L_i , C_i and L_i/R_i as applicable: with the application of those non-countable faults which result in the most onerous condition.

NOTE No faults are applied for thermal ignition compliance in accordance with [5.4](#).

Countable faults are not applied.

Only components which:

- define voltage or current for the purposes of spark ignition compliance, including components used to protect other components on which intrinsic safety depends,
- define U_o or I_o , or
- provide protection against polarity reversal in accordance with [6.8](#).

are required to conform to [7.1](#).

If applicable, P_o and P_i shall be determined under the most onerous normal operating conditions.

In assessing the circuits for spark ignition, a safety factor of 1,0 shall be applied in accordance with [5.3.4](#).

5.2.5 Non-shock hazard equipment or systems

Equipment or systems that are limited to extra low voltage and are designed according to other standards or regulations to prevent the risk of electric shock that might be hazardous to human health may be considered non-shock hazard equipment or systems.

EXAMPLE 1 Such other standards include SELV, PELV, ES1.

Where this document requires the application of U_m between connection facilities that are not galvanically isolated from each other, it is permitted to only consider application of the manufacturer's maximum rated voltage, providing the following requirements are met:

NOTE 1 The manufacturer's rated voltage is typically referred to as differential mode.

- a) the connection facilities shall only be connected to non-shock hazard equipment or systems.
- b) Where this document requires the application of U_m between connection facilities for circuits that employ galvanic isolation between the non-intrinsically safe circuit and other circuits, the applied voltage shall be the higher of:
 - U_m ; or
 - a voltage derived from the rated voltage or U_m , for example where the circuit has components that enhance the voltage to greater than U_m under normal operation.

NOTE 2 In this case the voltage across the galvanic isolation is typically referred to as common mode.

NOTE 3 Requirements for non-hazardous area accessories are detailed in [6.3.5](#).

- c) The certificate number shall include the "X" suffix in accordance with the marking requirements of IEC 60079-0 and the Specific Conditions of Use listed on the certificate shall:
- detail the requirements which apply to equipment or systems to be connected to the connection facilities, for example, they shall be SELV, PELV, ES1, or equivalent; and
 - state the permitted maximum voltage that may be applied between the non-intrinsically safe connection facilities that form a circuit within the apparatus.

NOTE 4 It is not a requirement of this document that a type or model for the supply be specified.

EXAMPLE 2 A serial data port is declared to have a U_m of 250 V AC_{RMS}, but with a maximum voltage between any two pins of the data port of 6 V. The circuit is assessed with 6 V differential mode applied between any two data port pins, but with 250 V AC_{RMS} common mode applied between the data port and galvanically isolated circuits (such as earth or the intrinsically safe circuits). The Specific Conditions of Use would state that the voltage applied to the serial data port connections is a maximum of 6 V and that only equipment complying with IEC 62368-1 may be used. Any galvanic isolation between the circuit of the data port and the intrinsically safe circuit would require separations for U_m (so in this example, 250 V AC_{RMS}).

5.3 Spark ignition compliance

5.3.1 General

Intrinsically safe circuits shall be assessed to ensure that at each point where an interruption or interconnection exposed to the explosive atmosphere is considered to occur, the available spark energy is incapable of causing ignition of the explosive atmosphere for the specified equipment group under the conditions and safety factors specified in [5.2](#) for the Level of Protection of the circuit.

NOTE The term "spark" is used throughout this document to refer to a make or break of the circuit under test. It is not necessary for such a make or break to produce a visible spark.

Spark ignition shall be assessed, except where stated otherwise in this document, as follows:

- a) across normally opening and closing contacts; and

EXAMPLE 1

Examples of normally opening and closing contacts are plugs and sockets, switches, pushbuttons and potentiometers that are user accessible without the use of a tool and are manually operated.

- b) at the connection facilities of intrinsically safe circuits, including connection of the applicable C_o , L_o and L_o/R_o specified for the connection facility. Unless stated otherwise in the instructions, C_o and L_o are applied separately when assessing the connection facility.

Spark ignition does not need to be considered:

- 1) across infallible separations complying with [6.5.4.2](#);
- 2) in series with infallible connections complying with [6.4.2](#);
- 3) within encapsulation meeting the requirements for protection against spark ignition specified in [6.6.1](#) and [6.6.2.1](#);
- 4) within associated apparatus other than at its intrinsically safe circuit connection facilities; or
- 5) between terminals of separate circuits conforming to [6.3.1](#).

For Group III circuits, the energy limits of Group IIB shall be applied.

Spark ignition assessment may use representative circuits that are at least as onerous for spark ignition in place of the actual circuit under assessment.

EXAMPLE 2 — spark ignition from a capacitor limited by a resistor complying with [7.4.2](#) can be considered as a resistive circuit with a fixed voltage;

— all the capacitors in a part of a circuit can be represented by a single capacitor equivalent to the sum of capacitance.

Spark ignition testing conducted according to [9.1](#) at normal ambient temperatures, and the ignition data in [Annex A](#) and [Annex G](#) may be used, where the service temperature is between $-60\text{ }^{\circ}\text{C}$ and $100\text{ }^{\circ}\text{C}$. No additional safety factors or consideration of heating due to faults within the apparatus are required. Equipment designed for use in service temperatures outside this range shall be subject to special investigation.

5.3.2 Levels of Protection "ia" and "ib"

For Levels of Protection "ia" and "ib", spark ignition assessment shall be applied to the following, except where stated otherwise in this document:

- a) at any interruption or interconnection (including failure of separation) of a circuit that is considered a countable or non-countable fault; and
- b) at any earth fault that is considered a countable or non-countable fault.

Spark ignition assessment (for example, application of the spark test apparatus) shall be carried out after the application of faults as specified in [5.2.2](#) and [5.2.3](#) and shall not add further to the fault count.

5.3.3 Level of Protection "ic"

For Level of Protection "ic", spark ignition assessment shall be applied to the following, except where stated otherwise in this document:

- a) across any separation of conductive parts whose failure is considered a non-countable fault according to [6.5.4](#); and
- b) in place of all or any part of components that are operated in excess of their manufacturer's specification under normal operating conditions.

Transients resulting from the application of U_m , which do not occur in normal operation (for example, as a result of a failure in the power supply), shall not be considered for the purposes of spark ignition compliance.

5.3.4 Application of safety factors

5.3.4.1 Safety factor 1,0

Where a safety factor of 1,0 is required by [5.2](#) for spark ignition assessment, it shall be obtained by one of the following methods:

- a) using the columns for safety factor of 1,0 in the tables in [Annex A](#);
- b) using the curves in [Annex A](#);
- c) using [Annex G](#) without removing the 1,5 safety factor; or
- d) testing according to [9.1](#) using test mixtures according to [9.1.3.1](#).

5.3.4.2 Safety factor 1,5

Where a safety factor of 1,5 is required by [5.2](#) for spark ignition assessment, it shall be obtained by one of the following methods:

- a) using the columns for safety factor of 1,5 in the tables in [Annex A](#).
- b) using the curves in [Annex A](#) or the columns for safety factor 1,0 in the tables in [Annex A](#) where, prior to the application of the curves or tables:
 - 1) for inductive circuits the current is increased by a factor of 1,5;
 - 2) for capacitive circuits the voltage is increased by a factor of 1,5; or
 - 3) for resistive circuits, the current is increased by a factor of 1,5, or, as a conservative alternative, the voltage may instead be increased by a factor of 1,5.
- c) using [Annex G](#) (the limit curves of which already include a safety factor of 1,5);
- d) testing according to [9.1](#) applying one of the following:
 - 1) starting with the current and voltage under the conditions specified in [5.2](#) and testing using the test mixtures specified in [9.1.3.1](#):
 - for inductive and resistive circuits, so far as practical the current is increased to 1,5 times the assessed current by decreasing the values of limiting resistance; where it is not practical to obtain the 1,5 safety factor in this way, the voltage is increased until the required current is obtained; or
 - for capacitive circuits, the voltage is increased by a factor of 1,5.
 - 2) where [5.3.4.2 d\) 1\)](#) is not practical, the use of more ignitable test mixtures according to [9.1.3.2](#);
- e) using [Annex F](#) (which applies the safety factor to the gas mixture).

NOTE The purpose of the application of a safety factor is to ensure either that a type test or theoretical assessment is carried out with a circuit which is demonstrably more likely to cause ignition than the original, or that the original circuit is tested in a more readily ignited gas mixture. In general, it is not possible to obtain exact equivalence between different methods of achieving a specified safety factor, but the methods stated in this document provide acceptable alternatives.

5.3.5 Circuits without controlled semiconductor limitation

Circuits for which intrinsic safety does not depend on controlled semiconductor limitation shall be assessed using one of the following:

- a) with the spark ignition test specified in [9.1](#);
- b) at the connection facilities of FISCO equipment: complying with the intrinsic safety parameter limits specified in [Annex E](#);
- c) by assessment as specified in [9.2](#);

EXAMPLE

For a trapezoidal output characteristic consisting of a voltage source followed by a resistor followed by a Zener diode, [9.2](#) can be used by assessing with the Zener diode removed from the circuit leaving a linear characteristic.

- d) for linear output characteristic, using [Annex G](#) for linear sources of power; or

- e) for trapezoidal output characteristic, using [Annex G](#) for rectangular sources of power.

NOTE A circuit assessed using the reference curves and tables of [Annex A](#) might cause ignition when tested using the spark test apparatus. Nevertheless, the tables can still be used for assessment because the sensitivity of the spark test apparatus varies, and the curves and tables are derived from a large number of such tests.

5.3.6 Circuits with controlled semiconductor limitation

Circuits for which intrinsic safety depends on the operation of controlled semiconductor limitation shall be assessed to ensure spark ignition compliance both in the steady state condition where limitation is not activated and for the transient response when the limitation is activated.

In both of these cases the assessment shall consider the worst-case load that the application is expected to encounter under the conditions specified in [5.2](#) both for the limiting circuit and the load. This load might be a resistance, a fixed voltage load (such as a Zener) or a constant current source load, in combination with the inductance and capacitance that may be present under these conditions.

Where the transient response of the limitation is tested using the spark test apparatus (either using [9.1](#) or [Annex F](#)), the circuit shall be arranged to ensure that it fully resets during the test between each main break and following make of the spark test apparatus. Make and break caused by bouncing of the tungsten wire on the cadmium disk need not be considered. The test may be carried out on a representative circuit where the reset time has been reduced from that of a production circuit.

Where connection facility parameters are limited by circuits with controllable semiconductor limitation, U_o and I_o shall be calculated from the steady state limits, and not the peak of the transient response.

Assessment may involve one or more of the following, as applicable, to demonstrate steady state and transient response compliance.

- a) compliance with the spark ignition test specified in [9.1](#);
- b) at the connection facilities of FISCO equipment: complying with the intrinsic safety parameter limits specified in [Annex E](#);
- c) where it is not practical to apply the safety factor to the voltage or current, compliance with [Annex F](#);
- d) for linear output characteristic assessed as specified in [9.2](#);
- e) steady state compliance may be demonstrated where the steady state output characteristic is fully contained within a linear characteristic that meets [Table A.1](#); transient state compliance may also be demonstrated where transient state characteristics are fully contained within a linear characteristic that meets [Table A.1](#).
- f) where there is no more than one controlled semiconductor current limitation supply directly connected to the circuit, steady state compliance may be demonstrated using [Annex G](#) for non-linear sources of power; and
- g) transient compliance may be assessed according to [Annex D](#).

Different methods may be used for steady state and transient response. Switching controlled semiconductor limitation shall not trigger or trip during any test used to demonstrate steady state compliance.

5.4 Thermal ignition compliance

5.4.1 General

All surfaces of intrinsically safe apparatus that come into contact with explosive atmospheres shall be assessed to ensure that, under the conditions specified in [5.2](#), the apparatus complies with the maximum surface temperature requirements of IEC 60079-0 as modified by:

- a) [5.4.2](#), [5.4.3](#), [5.4.4](#) for Groups I and II; and
- b) [5.4.5](#) for Group I, and for Group III.

The assessment shall be made without any additional factor required by IEC 60079-0 on the input voltage, current or power other than those required by this document.

Temperature classification may be assessed using thermal models based on knowledge of components' thermal behaviour or with reference to comparable apparatus. Tests, when required, shall be in accordance with [9.3](#).

Where the maximum power dissipation in tracks or wiring does not exceed 1,3 W, they shall be considered acceptable for a temperature classification of T4, or for Group I at a maximum ambient temperature of 40 °C. Where dust is excluded and the maximum power dissipation in the track or wiring does not exceed 3,3 W, they shall be considered suitable for Group I at a maximum ambient temperature of 40 °C. When using this assessment at ambient temperatures greater than 40 °C, these power limits shall be derated as specified in IEC 60079-0 for assessment of temperature classification for component surface area $\geq 20 \text{ mm}^2$.

5.4.2 Temperature of small components for Group I and Group II

Requirements for small component temperature for Group I or Group II electrical equipment of IEC 60079-0 apply, and the test requirements are provided in the small component ignition test of IEC 60079-0.

The 5 K and 10 K margin required by IEC 60079-0 in the type tests for determining maximum surface temperature applies to surface temperature requirements for [7.16.2.4b](#)) and for Level of Protection "ic".

The 5 K and 10 K margin required by IEC 60079-0 does not apply for surface temperature requirements for Levels of Protection "ia" or "ib" when the table for assessment of temperature classification according to component size for small components in IEC 60079-0 is used, otherwise, the margin applies.

5.4.3 Wiring within intrinsically safe apparatus for Group I and Group II

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

$$I = I_f \sqrt{\frac{(t - T_a)(1 + \alpha(T - T_a))}{(T - T_a)(1 + \alpha(t - T_a))}}$$

where

- α is the temperature coefficient of resistance of the wire material at T_a in K^{-1} ;
- I is the maximum permissible current RMS, in amperes;
- I_f is the current, in amperes, at which the wire melts in an ambient temperature T_a ;
- T is the melting temperature of the wire material in degrees Celsius (1 083 °C for copper, 1 064 °C for gold);
- T_a is the maximum ambient temperature in °C; and
- t is the threshold temperature, in °C, for thermal ignition compliance. This is also the resultant wire



temperature due to self-heating and ambient temperature.
Where the temperature coefficient of resistance of the material is specified at an ambient other than T_a , α_a at T_a can be determined as follows:

$$\alpha_a = \frac{1}{\left(\frac{1}{\alpha_r} + (T_a - T_r)\right)}$$

T_r is the known reference ambient temperature in °C (for example, 20 °C).
 α_r is the coefficient of resistance at T_r in K⁻¹ (for example, 0,004 27 K⁻¹ for copper, 0,004 201 K⁻¹ for gold at 20 °C)¹⁾.

Where the melting current of the wire is available at a different ambient temperature to T_a (for example, where the manufacturer of the wire specifies the melting current in the wire in an ambient of 20 °C),

$$I_f = I_r \sqrt{\frac{(T - T_a)}{(T - T_r)}}$$

where:
 I_r is the current, in amperes, at which the wire melts in an ambient temperature T_r
then I_f may be determined as follows:

EXAMPLE fine copper wire with a surface area less than 20 mm² (Temperature class = T4)

$\alpha = 0,004\ 27\ \text{K}^{-1}$

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

$T = 1\ 083\ ^\circ\text{C}$

$T_a = 40\ ^\circ\text{C}$

t for T4 (Small component, $t \leq 275\ ^\circ\text{C}$)

Applying the equation:

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

Table 3 — Temperature classification of copper wiring for ambient temperature ≤ 40 °C

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

^a Diameter and cross-sectional area are the nominal dimensions specified by the wire manufacturer.
The value given for maximum permissible current, in amperes, is the RMS AC or DC value.

1) Temperature coefficient of resistance of copper” by D.H Dellinger, Bulletin of the Bureau of Standards Vol 7 No 1 page 89, November 1910.

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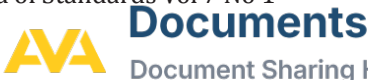
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Table 3 (continued)

Diameter ^a mm	Cross-sectional area ^a mm ²	Maximum permissible current for temperature classification A		
		T1 to T4 and Group I	T5	T6
For stranded conductors, the cross-sectional area is taken as the total area of all strands of the conductor. The table also applies to flexible circuit boards and flexible flat conductors, such as a ribbon cable, but not to rigid circuit conductors.				

5.4.4 PCB tracks for Group I and Group II

The temperature classification of PCB tracks exposed to the explosive atmosphere shall be determined using available analytical techniques and data or by testing. In all cases, the maximum continuous current shall be used to determine the temperature classification of a track. Tracks with lengths of 10 mm or less shall be disregarded for temperature classification purposes. Manufacturing tolerances shall not reduce the track width, board thickness or conductor thickness values determined in accordance with these requirements by more than 10 % or 1 mm, whichever is the smaller.

NOTE IPC-2221 and IPC-2152 are examples of available data.

Where the tracks are made of copper, the temperature classification may be determined using [Table 4](#). The values found in the table shall be adjusted depending on the actual board thickness, number of track layers, copper conductor thickness, ambient temperature, and whether the track passes under components dissipating more than 0,25 W. When applying [Table 4](#) and the associated adjustment factors, linear interpolation between current, track width, track thickness, ambient temperature, and board thickness values is allowed. No extrapolation of any values or adjustment factors is allowed. The maximum permissible current I_p is calculated as shown below:

$$I_p = I \times \lambda_B \times \lambda_L \times \lambda_T \times \lambda_C \times \lambda_A$$

where

- I is the maximum permissible current for temperature classification found in [Table 4](#);
- λ_B is the board thickness factor;
- λ_L is the number of layers factor;
- λ_T is the copper thickness factor;
- λ_C is the under component factor;
- λ_A is the ambient temperature factor.

EXAMPLE To find the maximum permissible current for a T5 ($T_{amb} = 60\text{ °C}$) rating of a 1 mm wide track that is greater than 10 mm in length on a two-layer circuit board with board thickness of 1,55 mm and copper conductor thickness of 18 µm that does not pass under power dissipating components.

[Table 4](#) maximum permissible current for T5 ($T_{amb} = 40\text{ °C}$) of a 1 mm wide track $I = 4,8\text{ A}$

$\lambda_B = 1,00$; $\lambda_L = 0,67$; $\lambda_T = 0,67$; $\lambda_C = 1,00$; $\lambda_A = 0,83$

$I_p = 4,8\text{ A} \times 1,00 \times 0,67 \times 0,67 \times 1,00 \times 0,83 = 1,79\text{ A}$

Table 4 — Temperature classification of tracks on PCBs

Minimum track width mm	Maximum permissible current for temperature classification (for a maximum ambient temperature of 40 °C)		
	T1 to T4 and Group I A	T5 A	T6 A
0,075	0,8	0,6	0,5



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Table 4 (continued)

Minimum track width mm	Maximum permissible current for temperature classification (for a maximum ambient temperature of 40 °C)		
	T1 to T4 and Group I A	T5 A	T6 A
0,1	1,0	0,8	0,7
0,125	1,2	1,0	0,8
0,15	1,4	1,1	1,0
0,2	1,8	1,4	1,2
0,3	2,4	1,9	1,7
0,4	3,0	2,4	2,1
0,5	3,5	2,8	2,5
0,7	4,6	3,5	3,2
1,0	5,9	4,8	4,1
1,5	8,0	6,4	5,6
2,0	9,9	7,9	6,9
2,5	11,6	9,3	8,1
3,0	13,3	10,7	9,3
4,0	16,4	13,2	11,4
5,0	19,3	15,5	13,5
6,0	22,0	17,7	15,4

The value given for maximum permissible current, in amperes, is the RMS AC or DC value.

This table applies to PCBs 1,55 mm or thicker with a single layer of copper of 33 µm thickness. The values found in the table shall be adjusted by multiplying the maximum permissible current found above by each of the factors below.

Board thickness (mm)	Factor (λ_B)
1,55	1,00
1,00	0,91
0,75	0,87
0,50	0,83
Number of track layers	Factor (λ_L)
1	1,00
2	0,67
> 2	0,50

Cu thickness (µm)	Factor (λ_T)
70	1,30
51	1,20
33	1,00
18	0,67

Under component ^a	Factor (λ_C)
No	1,00
Yes	0,67

Ambient temperature (°C)	Factor (λ_A)		
	T4	T5	T6
40	1,00	1,00	1,00
60	0,83	0,83	0,83
80	0,77	0,64	0,40
100	0,66	-	-

^a Applies to tracks passing under components dissipating 0,25 W or more, either normally or under fault conditions, where the section of track passing under the component exceeds a length of 10 mm.