IEC 60079-14

Edition 5.0 2013-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Explosive atmospheres –
Part 14: Electrical installations design, selection and erection

Atmosphères explosives –
Partie 14: Conception, sélection et construction des installations électriques

IEC 60079-14:2013

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 14: Electrical installations design, selection and erection

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60079-14 has been prepared by subcommittee 31J: Classification of hazardous areas and installation requirements, of IEC technical committee 31: Equipment for explosive atmospheres.

This fifth edition cancels and replaces the fourth edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

		Type		
Explanation of the significance of the changes	**Clause**	**Minor and editorial changes**	**Extension**	**Major technical changes**
Introduction of initial inspection	Scope		X	
Introduction of definition “electrical equipment”	3.1.3	X		
Introduction of definition “hybrid mixture”	3.2.4		X	
Note added to the definition “associated apparatus”	3.5.2	X		
Introduction of definition “radio frequency identification”	3.15	X		
List for documents improved and extended: site, equipment, installation and personnel	4.2	X		
New subclause for initial inspection	4.3		X	
Specific requirements given in this standard based on the current edition of the IEC standards in the IEC 60079 series.	4.4.1.2	X		
New selection criteria for radiating equipment according to IEC 60079-0	5.7		X	
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<tr><th colspan="2">A) Definitions</th></tr>
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– Decrease of technical requirements
– Minor technical change
– Editorial corrections</td></tr>
<tr><td colspan="2">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 the level of existing requirement.</td></tr>
<tr><td>2. Extension:</td><td>– Addition of technical options</td></tr>
<tr><td colspan="2">These are changes which add new or modify existing technical requirements, in a way that new options are given, but without increasing the requirements for the design, selection and erection of existing installations that are fully compliant with the previous standard. Therefore, these will not have to be considered for existing installations in conformity with the preceding edition.</td></tr>
<tr><td>3. Major technical changes:</td><td>– Addition of technical requirements
– Increase of technical requirements</td></tr>
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These changes represent the latest state-of-the-art technology. However, these changes should not normally have an influence on existing installations.</td></tr>
<tr><td colspan="2">B) Information about the background of “major technical changes”</td></tr>
<tr><td colspan="2">C1 Due to the risk of gassing producing hydrogen from all cell types, adequate provision for venting is required as the gassing can create an explosive condition in small enclosures. This condition would apply to torches, multi meters, pocket gas sensors and similar items. Alternatively, where the equipment meets the requirements for Equipment Group IIC, the requirement of degassing apertures or limitation of hydrogen concentration does not apply.

C2 An individual intrinsically safe circuit is also safe under short-circuit conditions. The short-circuit between two independent intrinsically safe circuits is not considered. Therefore the terminal boxes have to meet additional requirements for IP rating as well for the mechanical impact to make sure that the integrity of the enclosure is given also under worst case conditions.</td></tr>
</table>

The text of this standard is based on the following documents:

FDIS	Report on voting
31J/225/FDIS	31J/230/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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 publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication 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.

INTRODUCTION

Preventive measures to reduce the explosion risk from flammable materials are based on three principles, which are normally applied in the following order:

1) substitution
2) control
3) mitigation

Substitution involves, for example, replacing a flammable material by one which is either not flammable or less flammable.

Control involves, for example:

a) reducing the quantity of flammables;
b) avoiding or minimising releases;
c) controlling the release;
d) preventing the formation of an explosive atmosphere;
e) collecting and containing releases; and
f) avoiding ignition sources.

NOTE 1 With the exception of item f), all of the above are part of the process of hazardous area classification.

Mitigation involves, for example:

1) reducing the number of people exposed;
2) providing measures to avoid the propagation of an explosion;
3) providing explosion pressure relief;
4) providing explosion pressure suppression; and
5) providing suitable personal protective equipment.

NOTE 2 The above items are part of consequence management when considering risk.

Once the principles of substitution and control (items a) to e)) have been applied, the remaining hazardous areas should be classified into zones according to the likelihood of an explosive atmosphere being present (see IEC 60079-10-1 or IEC 60079-10-2). Such classification, which may be used in conjunction with an assessment of the consequences of an ignition, allows equipment protection levels to be determined and hence appropriate types of protection to be specified for each location.

For an explosion to occur, an explosive atmosphere and a source of ignition need to co-exist. Protective measures aim to reduce, to an acceptable level, the likelihood that the electrical installation could become a source of ignition.

By careful design of the electrical installation, it is frequently possible to locate much of the electrical equipment in less hazardous or non-hazardous areas.

When electrical equipment is installed in areas where explosive concentrations and quantities of flammable gases vapours or dusts may be present in the atmosphere, protective measures are applied to reduce the likelihood of explosion due to ignition by arcs, sparks or hot surfaces, produced either in normal operation or under specified fault conditions.

Many types of dust that are generated, processed, handled and stored, are combustible. When ignited they can burn rapidly and with considerable explosive force if mixed with air in the appropriate proportions. It is often necessary to use electrical equipment in locations where such materials are present, and suitable precautions should therefore be taken to ensure that all such equipment is adequately protected so as to reduce the likelihood of ignition of the external explosive atmosphere. In electrical equipment, potential ignition sources include electrical arcs and sparks, hot surfaces and frictional sparks.

Dust can be ignited by equipment in several ways:

- by surfaces of the equipment that are above the minimum ignition temperature of the dust concerned. The temperature at which a type of dust ignites is a function of the properties of the dust, whether the dust is in a cloud or layer, the thickness of the layer and the geometry of the heat source;
- by arcing or sparking of electrical parts such as switches, contacts, commutators, brushes, or the like;
- by discharge of an accumulated electrostatic charge;
- by radiated energy (e.g. electromagnetic radiation);
- by mechanical sparking or frictional sparking associated with the equipment.

In order to avoid dust ignition hazards it is important that:

- the temperature of surfaces on which dust can be deposited, or which would be in contact with a dust cloud, is kept below the temperature limitation specified in this standard;
- any electrical sparking parts, or parts having a temperature above the temperature limit specified in this standard:
  - are contained in an enclosure which adequately prevents the ingress of dust, or
  - the energy of electrical circuits is limited so as to avoid arcs, sparks or temperatures capable of igniting dust;
- any other ignition sources are avoided.

Several types of protection are available for electrical equipment in hazardous areas (see IEC 60079-0), and this standard gives the specific requirements for design, selection and erection of electrical installations in explosive atmospheres.

This part of the IEC 60079 series is supplementary to other relevant IEC standards, for example IEC 60364 series as regards electrical installation requirements. This part also refers to IEC 60079-0 and its associated standards for the construction, testing and marking requirements of suitable electrical equipment.

This standard provides the specific requirements for the design, selection, erection and the required initial inspection of electrical equipment in hazardous areas. This standard is also based on manufacturer's instructions being followed. On-going inspection, maintenance and repair aspects also play an important role in control of hazardous area installations and the user's attention is drawn to IEC 60079-17, IEC 60079-19 and manufacturer's instructions for further information concerning these aspects.

In any industrial installation, irrespective of size, there may be numerous sources of ignition apart from those associated with electrical equipment. Precautions may be necessary to ensure safety from other possible ignition sources, but guidance on this aspect is outside the scope of this standard.

EXPLOSIVE ATMOSPHERES –

Part 14: Electrical installations design, selection and erection

1 Scope

This part of the IEC 60079 series contains the specific requirements for the design, selection, erection and initial inspection of electrical installations in, or associated with, explosive atmospheres.

Where the equipment is required to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion, additional protection requirements may be necessary.

The requirements of this standard apply only to the use of equipment under standard atmospheric conditions as defined in IEC 60079-0. For other conditions, additional precautions may be necessary, and the equipment should be certified for these other conditions. For example, most flammable materials and many materials which are normally regarded as non-flammable might burn vigorously under conditions of oxygen enrichment.

NOTE 1 The standard atmospheric conditions defined in IEC 60079-0 relate to the explosion characteristics of the atmosphere and not the operating range of the equipment i.e.

- Temperature: –20 °C to 60 °C;
- Pressure: 80 kPa (0,8 bar) to 110 kPa (1,1 bar); and
- air with normal oxygen content, typically 21 % v/v.

These requirements are in addition to the requirements for installations in non-hazardous areas.

NOTE 2 For voltages up to 1 000 V a.c. or 1 500 V d.c. requirements of this standard are based on installation requirements in the IEC 60364 series, but other relevant national requirements can apply.

This standard applies to all electrical equipment including fixed, portable, transportable and personal, and installations, permanent or temporary.

This standard does not apply to

– electrical installations in mines susceptible to firedamp;

NOTE 3 This standard can apply to electrical installations in mines where explosive gas atmospheres other than firedamp can be formed and to electrical installations in the surface installation of mines.

– inherently explosive situations and dust from explosives or pyrophoric substances (for example explosives manufacturing and processing);
– rooms used for medical purposes;
– electrical installations in areas where the hazard is due to flammable mist.

NOTE 4 Additional guidance on the requirements for hazards due to hybrid mixtures of dust or flyings and flammable gas or vapour is provided in Annex M.

No account is taken in this Standard of the toxic risks that are associated with flammable gases, liquids and dusts in concentrations that are usually very much less than the lower explosive limit. In locations where personnel may be exposed to potentially toxic concentrations of flammable material, appropriate precautions should be taken. Such precautions are outside the scope of this Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60060-1, *High-voltage test techniques - Part 1: General definitions and test requirements*

IEC 60079 (all parts), *Explosive atmospheres*

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

IEC 60079-1, *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60079-6, *Explosive atmospheres – Part 6: Equipment protection by oil immersion "o"*

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

IEC 60079-10-1, *Explosive atmospheres – Part 10-1: Classification of areas - Explosive gas atmospheres*

IEC 60079-10-2, *Explosive atmospheres – Part 10-2: Classification of areas – Combustible dust atmospheres*

IEC 60079-11, *Explosive atmospheres – Part 11: Equipment protection by intrinsic safety "i"*

IEC 60079-13, *Explosive atmospheres – Part 13: Equipment protection by pressurized room "p"*

IEC 60079-15, *Explosive atmospheres – Part 15: Equipment protection by type of protection "n"*

IEC/TR 60079-16, *Electrical apparatus for explosive gas atmospheres – Part 16: Artificial ventilation for the protection of analyzer(s) houses*

IEC 60079-17, *Explosive atmospheres – Part 17: Electrical installations inspection and* maintenance

IEC 60079-18, *Explosive atmospheres – Part 18: Equipment protection by encapsulation "m"*

IEC 60079-19, *Explosive atmospheres – Part 19: Equipment repair, overhaul and reclamation*

IEC 60079-26, *Explosive atmospheres – Part 26: Equipment with equipment protection level (EPL) “Ga”*

IEC 60079-28, *Explosive atmospheres – Part 28: Protection of equipment and transmission systems using optical radiation*

IEC 60079-29-1, *Explosive atmospheres – Part 29-1: Gas detectors – Performance requirements of detectors for flammable gases*

IEC 60079-29-4, *Explosive atmospheres – Part 29-4: Gas detectors – Performance requirements of open path detectors for flammable gases*

IEC 60079-30-1, *Explosive atmospheres – Part 30-1: Electrical resistance trace heating – General and testing requirements*

IEC 60243-1, *Electrical strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60950 (all parts), *Information technology equipment – Safety*

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

IEC 61285, *Industrial process control – Safety of analyser houses*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 62305-3:2010, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

3 Terms and definitions

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

NOTE Additional definitions applicable to explosive atmospheres can be found in IEC 60050-426.

3.1 General

3.1.1
competent body
individual or organization which can demonstrate appropriate technical knowledge and relevant skills to make the necessary assessments of the safety aspect under consideration

3.1.2
verification dossier
set of documents showing the compliance of electrical equipment and installations

3.1.3
electrical equipment
items applied as a whole or in part for the utilization of electrical energy

Note 1 to entry: These include, amongst others, items for the generation, transmission, distribution, storage, measurement, regulation, conversion and consumption of electrical energy and items for telecommunications.

3.2 Hazardous areas

3.2.1
hazardous area
area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment

Note 1 to entry: For the purposes of this standard, an area is a three-dimensional region or space.

3.2.2
non-hazardous area
area in which an explosive atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment

3.2.3
group <of electrical equipment for explosive atmospheres>
classification of electrical equipment related to the explosive atmosphere for which it is to be used

Note 1 to entry: Electrical equipment for use in explosive atmospheres is divided into three groups:

– Group I: electrical equipment for mines susceptible to firedamp;
– Group II (which can be divided into subgroups): electrical equipment for places with an explosive gas atmosphere, other than mines susceptible to firedamp (see 5.5);
– Group III (which can be divided into subgroups): electrical equipment for places with an explosive dust atmosphere (see 5.5).

3.2.4
hybrid mixture
mixture of a flammable gas or vapour with a combustible dust

Note 1 to entry: According IEC 60079-10-2 the term “dust” is defined as including both dust and flyings.

3.2.5
maximum permissible surface temperature
highest temperature that a surface of electrical equipment is allowed to reach in practical service to avoid ignition

Note 1 to entry: This definition does not apply to gases. The maximum permissible surface temperature will depend upon the type of dust, whether as a cloud or layer, including layer thickness and the application of a safety factor (see 5.6.3).

3.2.6
zones
hazardous areas classified into zones based upon the frequency of the occurrence and duration of an explosive atmosphere

3.2.7
Zone 0
place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas or vapour is present continuously or for long periods or frequently

3.2.8
Zone 1
place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas or vapour is likely to occur in normal operation occasionally

3.2.9
Zone 2
place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas or vapour is not likely to occur in normal operation but, if it does occur, will persist for a short period only

3.2.10
Zone 20
area in which an explosive atmosphere in the form of a cloud of dust in air is present continuously, or for long periods or frequently

3.2.11
Zone 21
area in which an explosive atmosphere in the form of a cloud of dust in air is likely to occur, occasionally, in normal operation

3.2.12
Zone 22
area in which an explosive atmosphere in the form of a cloud of dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only

3.3 Flameproof enclosure

3.3.1
flameproof enclosure "d"
type of protection in which the parts capable of igniting an explosive gas atmosphere are provided with an enclosure which can withstand the pressure developed during an internal explosion of an explosive mixture and which prevents the transmission of the explosion to the explosive gas atmosphere surrounding the enclosure

3.3.2
pressure-piling
increased pressure resulting from an ignition, in a compartment or subdivision of an enclosure due to a gas mixture being pre-compressed, e.g. due to a primary ignition in another compartment or subdivision

Note 1 to entry: This may lead to a higher maximum pressure than would otherwise be expected.

3.4 Increased safety

3.4.1
increased safety "e"
type of protection applied to electrical equipment in which additional measures are applied so as to give increased security against the possibility of excessive temperatures and of the occurrence of arcs and sparks in normal service or under specified abnormal conditions

3.4.2
initial starting current
I_A
highest r.m.s. value of current absorbed by an a.c. motor at rest or by an a.c. magnet with its armature clamped in the position of maximum air gap, when supplied at the rated voltage and rated frequency

3.4.3
starting current ratio
I_A/I_N
ratio between initial starting current I_A and rated current I_N

3.4.4
time
t_E
time taken for an a.c. rotor or stator winding, when carrying the initial starting current I_A, to be heated up to the limiting temperature from the temperature reached in rated service at the maximum ambient temperature

3.5 Intrinsic safety

3.5.1
intrinsic safety "i"
type of protection based upon the restriction of electrical energy within the apparatus and of interconnecting wiring exposed to an explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects

3.5.2
associated apparatus
electrical apparatus which contains both intrinsically safe circuits and non-intrinsically safe circuits and is constructed so that the non-intrinsically safe circuits cannot adversely affect the intrinsically safe circuits

Note 1 to entry: Associated apparatus may be either:

a) electrical equipment which has another type of protection listed in IEC 60079-0 for use in the appropriate explosive atmosphere, or
b) electrical equipment not so protected and which, therefore, is not normally used within an explosive atmosphere, for example a recorder which is not itself in an explosive atmosphere, but is connected to a thermocouple situated within an explosive atmosphere where only the recorder input circuit is intrinsically safe.

3.5.3
intrinsically safe apparatus
electrical apparatus in which all the circuits are intrinsically safe

3.5.4
galvanic isolation
arrangement within an item of intrinsically safe apparatus or associated apparatus which permits the transfer of signals or power between two circuits without any direct electrical connection between the two

Note 1 to entry: Galvanic isolation frequently utilizes either magnetic (transformer or relay) or opto-coupled elements.

3.5.5
simple apparatus
electrical component or combination of components of simple construction with well-defined electrical parameters which is compatible with the intrinsic safety or energy-limited safety of the circuit in which it is used

3.5.6
intrinsically safe circuit
circuit in which any spark or any thermal effect produced in 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

Note 1 to entry: The circuit may also contain associated apparatus.

3.5.7
intrinsically safe electrical system
assembly of interconnected items of electrical equipment, described in a descriptive system document, in which the circuits or parts of circuits intended to be used in an explosive atmosphere are intrinsically safe

3.5.8
intrinsically safe sub-circuit
part of an intrinsically safe circuit which is galvanically isolated from another part or other parts of the same intrinsically safe circuit

3.6 Intrinsic safety parameters

3.6.1
maximum external inductance to resistance ratio
L_o/R_o
maximum value of ratio of inductance to resistance that can be connected to the external connection facilities of the electrical apparatus without invalidating intrinsic safety

3.7 Pressurization

3.7.1
pressurization "p"
technique of guarding against the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere

3.7.2
continuous dilution
continuous supply of a protective gas, after purging, at such a rate that the concentration of a flammable substance inside the pressurized enclosure is maintained at a value outside the explosive limits at any potential ignition source (that is, outside the dilution area)

Note 1 to entry: The dilution area is an area in the vicinity of an internal source of release where the concentration of a flammable substance is not diluted to a safe concentration.

3.7.3
leakage compensation
flow of protective gas sufficient to compensate for any leakage from the pressurized enclosure and its ducts

3.7.4
static pressurization
maintenance of an overpressure within a pressurized enclosure without the addition of protective gas in the hazardous area

3.8 Type of protection "n"

3.8.1
type of protection "n"
type of protection applied to electrical equipment such that, in normal operation and in certain specified abnormal conditions, it is not capable of igniting a surrounding explosive atmosphere

Note 1 to entry: Additionally, the requirements of the equipment standard are intended to ensure that a fault capable of causing ignition is not likely to occur.

Note 2 to entry: An example of a specified abnormal condition is a luminaire with a failed lamp.

3.8.2
energy-limited apparatus
electrical equipment in which the circuits and components are constructed according to the concept of energy limitation

3.8.3
associated energy-limited apparatus
electrical equipment which contains both energy-limited and non-energy-limited circuits and is constructed so that the non-energy-limited circuits cannot adversely affect the energy-limited circuits

3.9 oil-immersion “o”

type of protection in which the electrical equipment or parts of the electrical equipment are immersed in a protective liquid in such a way that an explosive gas atmosphere which may be above the liquid or outside the enclosure cannot be ignited

3.10 powder filling “q”

type of protection in which the parts capable of igniting an explosive gas atmosphere are fixed in position and completely surrounded by filling material to prevent the ignition of an external explosive atmosphere

Note 1 to entry: The type of protection may not prevent the surrounding explosive gas atmosphere from penetrating into the equipment and components and being ignited by the circuits. However, due to the small free volumes in the filling material and due to the quenching of a flame which may propagate through the paths in the filling material, an external explosion is prevented.

3.11 encapsulation “m”

type of protection whereby parts that are capable of igniting an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that the explosive atmosphere cannot be ignited under operating or installation conditions

3.12 protection by enclosure “t”

type of protection whereby all electrical equipment is protected by an enclosure to avoid ignition of a dust layer or cloud

3.13 Electrical supply systems

3.13.1
protective extra-low voltage system
PELV
electric system in which the voltage cannot exceed the value of extra-low voltage:

– under normal conditions, and
– under single fault conditions, except earth faults in other electric circuits

[SOURCE: IEC 60050-826:2004, 826-12-32]

3.13.2
safety extra-low voltage system
SELV
electric system in which the voltage cannot exceed the value of extra-low voltage:

– under normal conditions and
– under single fault conditions, including earth faults in other electric circuits

[SOURCE: IEC 60050-826:2004, 826-12-31]

3.14 Equipment

3.14.1
fixed
equipment fastened to a support, or otherwise secured in a specific location when energized

3.14.2
transportable
equipment not intended to be carried by a person nor intended for fixed installation which can be moved when energized

3.14.3
portable
equipment intended to be carried by a person which can be moved when energized

3.14.4
personal
equipment intended to be supported by a person's body during normal use

3.15 radio frequency identification
RFID

data collection technology that uses electronic tags for storing data

Note 1 to entry: The tag, also known as an "electronic label", "transponder" or "type plate" is made up of an RFID chip attached to an antenna. Transmitting in the kilohertz, megahertz and gigahertz ranges, tags may be battery-powered or derive their power from the RF waves coming from the reader.

Note 2 to entry: This note applies to the French language only.

4 General

4.1 General requirements

Hazardous areas are classified into Zones 0, 1 and 2 for gases and vapours according to IEC 60079-10-1, and into Zones 20, 21 and 22 for dusts according to IEC 60079-10-2 in order to facilitate the selection of appropriate electrical equipment and the design of suitable electrical installations.

Electrical equipment should, as far as is reasonably practicable, be located in non-hazardous areas. Where it is not possible to do this, it should be located in an area where an explosive atmosphere is least likely to occur.

Electrical installations in hazardous areas shall also comply with the appropriate requirements for electrical installations in non-hazardous areas. However the requirements for non-hazardous areas are insufficient for installations in hazardous areas.

Where additional protection is required to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion the method used shall not adversely affect the integrity of the equipment. Electrical equipment and materials shall be installed and used within their electrical ratings for power, voltage, current, frequency, duty and such other characteristics where non-conformity might jeopardize the safety of the installation. In particular, care shall be taken to ensure that the voltage and frequency are appropriate to the supply system with which the equipment is used and that the temperature classification has been established for the correct voltage, frequency and other parameters.

Products for use in hazardous areas are commonly designed for IEC standard voltages according IEC 60038. If a supply voltage is outside of these standardized voltages, then equipment should be specially selected and certified.

All electrical equipment and wiring in hazardous areas shall be selected and installed in accordance with Clauses 5 to 13 inclusive and the additional requirements for the particular type of protection (Clauses 14 to 23).

Installations should be designed and equipment and materials installed with a view to providing ease of access for inspection and maintenance (IEC 60079-17).

Equipment and systems used in exceptional circumstances, for example research, development, pilot plant where explosion protected equipment is not available, need not meet the requirements of this standard, provided that the installation is under the supervision of a competent body and one or more of the following conditions, as appropriate, are met:

– measures are taken to ensure that an explosive atmosphere does not occur; or
– measures are taken to ensure that this equipment is disconnected before an explosive atmosphere occurs, in which case ignition after disconnection, e.g. due to heated parts, shall be prevented also; or
– measures are taken to ensure that persons and the environment are not endangered by fires or explosions.

In addition, the measures or conditions or control shall be documented by a competent body who:

– is familiar with the requirements for this, and any other relevant standards and code of practice concerning the use of electrical equipment and systems for use in hazardous areas, and,
– has access to all information necessary to carry out the assessment.

4.2 Documentation

It is necessary to ensure that any installation complies with the relevant equipment certificate (see also Clause 5) as well as with this standard and any other requirements specific to the plant on which the installation takes place. To achieve this result, a verification dossier shall be prepared for every installation and shall be either kept on the premises or stored in another location. In the latter case, a document shall be left on the premises indicating who the owner or owners are and where that information is kept, so that when required, copies may be obtained.

NOTE The verification dossier can be kept as hard copy or in electronic form. Methods accepted by legislation in each country can have an impact on the form in which the documentation will be legally accepted.

In order to correctly install or extend an existing installation, the following information, additional to that required for non-hazardous areas, is required as part of the verification dossier, where applicable:

SITE

– area classification documents (see IEC 60079-10-1 and IEC 60079-10-2) with plans showing the classification and extent of the hazardous areas including the zoning (and maximum permissible dust layer thickness if the hazard is due to dust);
– optional assessment of consequences of ignition (see 5.3);
– where applicable, gas, vapour or dust classification in relation to the group or subgroup of the electrical equipment;
– temperature class or ignition temperature of the gas or vapour involved;
– where applicable, the material characteristics including electrical resistivity, the minimum ignition temperature of the dust cloud, minimum ignition temperature of the dust layer and minimum ignition energy of the dust cloud;
– external influences and ambient temperature (see 5.9).

EQUIPMENT

– manufacturer's instructions for selection, installation and initial inspection;
– documents for electrical equipment with conditions of use, e.g. for equipment with certificate numbers which have the suffix "X";
– descriptive system document for the intrinsically safe system (see 16.2.4.2);

– details of any relevant calculation, e.g. for purging rates for instruments or analyser houses;
– manufacturer's/qualified person's declaration (see 4.4.2).

Consideration should be given to obtaining information for maintenance and repair to meet the requirements of IEC 60079-17 and IEC 60079-19 respectively.

INSTALLATION

– necessary information to ensure correct installation of the equipment provided in a form which is suitable to the personnel responsible for this activity (see IEC 60079-0, Instructions);
– documentation relating to the suitability of the equipment for the area and environment to which it will be exposed, e.g. temperature ratings, type of protection, IP rating, corrosion resistance;
– the plans showing types and details of wiring systems;
– records of selection criteria for cable entry systems for compliance with the requirements for the particular type of protection;
– drawings and schedules relating to circuit identification;
– records of the initial inspection (Annex C).
– installer's/qualified person's declaration (see 4.5)

NOTE Records of inspection for assemblies or pre-installed items can be accepted as part of initial inspection records.

4.3 Initial inspection

Equipment shall be installed in accordance with its documentation. It shall be ensured that replaceable items are of the correct type and rating. On completion of the erection and prior to first use, initial detailed inspection of the equipment and installation shall be carried out in accordance with Annex C, which is based on the "detailed" grade of inspection in IEC 60079-17.

NOTE IEC 60079-17 includes further information relevant to the initial inspection.

4.4 Assurance of conformity of equipment

4.4.1 Equipment with certificates according to IEC standards

4.4.1.1 General

Equipment with certificate according to the IEC 60079 series or the IEC 61241 series, meets the requirements for hazardous areas, when selected and installed in accordance with this standard.

4.4.1.2 IEC standards

The requirements given in this standard are based on the current editions of the IEC standards in the IEC 60079 series. If equipment is not certified in accordance with current editions of the IEC 60079 series it may not be compatible with the requirements given in this standard. It may be required that additional measures should be applied to ensure safe operation.

NOTE Information about the current editions of IEC standards, either for product safety or for equipment for explosive atmospheres, can be found on the IEC website. Information about the changes related to the previous editions is given in the foreword of the standards.

4.4.2 Equipment without certificates according to IEC standards

Apart from simple apparatus used within an intrinsically safe circuit, the selection of equipment for use in a hazardous area, which either has no certificate at all or it has a certificate but not in accordance with one of the standards listed in 4.4.1, shall be restricted to circumstances where equipment with suitable certification is not obtainable. The justification for the use of such equipment, along with the installation and marking requirements, shall be made by the user, manufacturer or third party and be recorded in the verification dossier. The following requirements of this standard, under these conditions, may not be applicable.

4.4.3 Selection of repaired, second hand or existing equipment

When it is intended that existing, second hand or repaired equipment is to be installed in a new installation, it shall only be reused if:

– it can be verified that the equipment is unmodified and is in a condition that meets the content of the original certificate (including any repair or overhaul). If there is doubt that the equipment is unmodified the original manufacturer should be contacted,
– any changes to equipment standards relevant to the item considered do not require additional safety precautions, and
– the basis used for the certification of that product does not conflict with the requirements given in this standard.

The act of introducing equipment where specifications are not identical to an existing installation may cause that installation to be deemed “new”.

In the situation where equipment is dual certified (e.g. as intrinsically safe apparatus and independently as flameproof equipment) care should be taken that the type of protection used for its new intended location has not been compromised by the way in which it was originally installed and subsequently maintained. Different protection concepts have different maintenance requirements. In the above example: equipment originally installed as flameproof should only be used as flameproof unless it can be verified that there has been no damage to the safety components within the intrinsically safe circuit on which safety depends by, for example, an over-voltage at the supply terminals or if it was originally installed as intrinsically safe then a check is required to ensure that there has been no damage to the flame paths before it can be used as flameproof.

4.5 Qualifications of personnel

The design of the installation, the selection of equipment and the erection covered by this standard shall be carried out only by persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken (see Annex A).

Appropriate continuing education or training shall be undertaken by personnel on a regular basis.

NOTE Competency can be demonstrated in accordance with a training and assessment framework relevant to national regulations or standards or user requirements.

5 Selection of equipment

5.1 Information requirements

In order to select the appropriate electrical equipment for hazardous areas, the following information is required:

– classification of the hazardous area including the equipment protection level requirements where applicable;
– where applicable, gas, vapour or dust classification in relation to the group or subgroup of the electrical equipment;
– temperature class or ignition temperature of the gas or vapour involved;

– minimum ignition temperature of the dust cloud and minimum ignition temperature of the dust layer;
– intended application of the equipment;
– external influences and ambient temperature.

It is recommended that the equipment protection levels (EPL) requirements are recorded on the area classification drawing. This should also apply even if consequences have not been subjected to risk assessment (see 5.3).

5.2 Zones

Hazardous areas are classified into zones. Zoning does not take account of the potential consequences of an explosion.

NOTE Editions of this standard prior to IEC 60079-14: 2007 (edition 4) allocated types of protection to zones, on a statistical basis such that where there was a more frequent probability of the occurrence of an explosive atmosphere, then a greater level of safety against the possibility of an ignition source was applied.

5.3 Relationship between equipment protection levels (EPLs) and zones

Where only the zones are indentified in the area classification documentation, then the relationship between EPLs and zones from Table 1 shall be followed.

Table 1 – Equipment protection levels (EPLs) where only zones are assigned

Zone	Equipment protection levels (EPLs)
0	“Ga”
1	“Ga” or “Gb”
2	“Ga”, “Gb” or “Gc”
20	“Da”
21	“Da” or “Db”
22	“Da”, “Db” or “Dc”

Where the EPLs are identified in the area classification documentation, those requirements for selection of the equipment shall be followed.

As an alternative to the relationship given in Table 1 between EPLs and zones, EPLs can be determined on the basis of a risk, i.e. taking into account the consequences of an ignition. This may, under certain circumstances, require a higher EPL or permit a lower EPL than that defined in Table 1. Refer to IEC 60079-10-1 and IEC 60079-10-2.

5.4 Selection of equipment according to EPLs

5.4.1 General

For new installations or equipment use, conformity of equipment shall be verified according to 4.4.

5.4.2 Relationship between EPLs and types of protection

The recognised types of protection according to IEC standards have been allocated default EPLs according to Table 2. Where the equipment is marked with a type of protection code and an EPL that differs from Table 2 then the equipment EPL marking shall take precedence.

Table 2 – Default relationship between types of protection and EPLs

EPL	Type of protection	Code	According to
“Ga”	Intrinsically safe	“ia”	IEC 60079-11
	Encapsulation	“ma”	IEC 60079-18
	Two independent types of protection each meeting EPL “Gb”		IEC 60079-26
	Protection of equipment and transmission systems using optical radiation	“op is”	IEC 60079-28
	Special protection	“sa”	IEC 60079-33
“Gb”	Flameproof enclosures	“d”	IEC 60079-1
	Increased safety	“e”	IEC 60079-7
	Intrinsically safe	“ib”	IEC 60079-11
	Encapsulation	“m” “mb”	IEC 60079-18
	Oil immersion	“o”	IEC 60079-6
	Pressurized enclosures	“p”, “px”, “py”, “pxb” or “pyb”	IEC 60079-2
	Powder filling	“q”	IEC 60079-5
	Fieldbus intrinsically safe concept (FISCO)		IEC 60079-27
	Protection of equipment and transmission systems using optical radiation	“op is” “op sh” “op pr”	IEC 60079-28
	Special protection	“sb”	IEC 60079-33
“Gc”	Intrinsically safe	“ic”	IEC 60079-11
	Encapsulation	“mc”	IEC 60079-18
	Non-sparking	“n” or “nA”	IEC 60079-15
	Restricted breathing	“nR”	IEC 60079-15
	Energy limitation	“nL”	IEC 60079-15
	Sparking equipment	“nC”	IEC 60079-15
	Pressurized enclosures	“pz” or “pzc”	IEC 60079-2
	Protection of equipment and transmission systems using optical radiation	“op is” “op sh” “op pr”	IEC 60079-28
	Special protection	“sc”	IEC 60079-33
“Da”	Encapsulation	“ma”	IEC 60079-18
	Protection by enclosure	“ta”	IEC 60079-31
	Intrinsically safe	“ia” or “iaD”	IEC 60079-11 or IEC 61241-11
	Special protection	“sa”	IEC 60079-33
“Db”	Encapsulation	“mb”	IEC 60079-18
	Protection by enclosure	“tb” or “tD”	IEC 60079-31 IEC 61241-1
	Pressurized enclosures	“pD”	IEC 61241-4
	Intrinsically safe	“ib” or “ibD”	IEC 60079-11 or IEC 61241-11

EPL	Type of protection	Code	According to
	Special protection	“sb”	IEC 60079-33
“Dc”	Encapsulation	“mc”	IEC 60079-18
	Protection by enclosure	“tc” or “tD”	IEC 60079-31 IEC 61241-1
	Pressurized enclosures	“pD”	IEC 61241-4
	Intrinsically safe	“ic”	IEC 60079-11
	Special protection	“sc”	IEC 60079-33
New protection marking codes with identification of EPLs may be introduced in the future.			

5.4.3 Equipment for use in locations requiring EPL “Ga” or “Da”

Electrical equipment and circuits can be used in locations requiring EPL “Ga” or “Da” if the equipment is either marked as EPL “Ga” or “Da” respectively or uses a type of protection listed in Table 2 as meeting the requirements of EPL “Ga” or “Da” respectively. The installation shall comply with the requirements of this standard as appropriate to the type of protection employed. When “Ga” is marked in accordance with IEC 60079-26 for combined types of protection, the installation shall simultaneously comply with the requirements of this standard as appropriate to the types of protection employed.

5.4.4 Equipment for use in locations requiring EPL “Gb” or “Db”

Electrical equipment and circuits can be used in locations requiring EPL “Gb” or “Db” if the equipment is either marked as EPL “Ga” or “Gb” and “Da” or “Db” respectively or uses a type of protection listed in Table 2 as meeting the requirements of EPL “Ga” or “Gb” and “Da” or “Db” respectively. The installation shall comply with the requirements of this standard as appropriate to the type of protection employed.

Where equipment meeting the requirements of EPL “Ga” or “Da” is installed in a location which only requires equipment to EPL “Gb” or “Db” respectively, it shall be installed in full accordance with the requirements of all the types of protection employed except as varied by the additional requirements for the individual protection techniques.

5.4.5 Equipment for use in locations requiring EPL “Gc” or “Dc”

Electrical equipment and circuits can be used in locations requiring EPL “Gc” or “Dc” respectively if the equipment is either marked as EPL “Ga” or “Gb” or, “Gc” and “Da” or “Db” or “Dc” respectively, or uses any type of protection listed in Table 2. The installation shall comply with the requirements of this standard as appropriate to the type of protection employed.

Where equipment meeting the requirements of EPL “Ga” or “Gb” and “Da” or “Db” respectively is installed in a location which only requires equipment to EPL “Gc” or “Dc” it shall be installed in full accordance with the requirements of all the types of protection employed except as varied by the additional requirements for the individual protection techniques.

5.5 Selection according to equipment grouping

Electrical equipment shall be selected in accordance with Table 3.

Table 3 – Relationship between gas/vapour or dust subdivision and equipment group

Location gas/vapour or dust subdivision	Permitted equipment group
IIA	II, IIA, IIB or IIC
IIB	II, IIB or IIC
IIC	II or IIC
IIIA	IIIA, IIIB or IIIC
IIIB	IIIB or IIIC
IIIC	IIIC

Where electrical equipment is marked indicating suitability with a particular gas or vapour, it shall not be used with other gases or vapours without a thorough assessment being carried out by a competent body and the assessment results showing that it is suitable for such use.

5.6 Selection according to the ignition temperature of the gas, vapour or dust and ambient temperature

5.6.1 General

The electrical equipment shall be so selected that its maximum surface temperature will not reach the ignition temperature of any gas, vapour or dust which may be present.

If the marking of the electrical equipment does not include an ambient temperature range, the equipment is designed to be used within the temperature range –20 °C to 40 °C. If the marking of the electrical equipment includes an ambient temperature range, the equipment is designed to be used within this range.

If the ambient temperature is outside the temperature range, or if there is a temperature influence from other factors, e.g. the process temperature or exposure to solar radiation, the effect on the equipment shall be considered and measures taken documented.

Cable glands normally do not have a temperature class or ambient operating temperature range marking. They do have a rated service temperature and unless marked, the service temperature is by default in a range of –20 °C to 80 °C. If different service temperatures are required, care should be taken, that the cable gland and the associated parts are suitable for such applications.

5.6.2 Gas or vapour

Symbols for the temperature classes marked on the electrical equipment have the meaning indicated in Table 4.

Table 4 – Relationship between gas or vapour ignition temperature and temperature class of equipment

Temperature class required by the area classification	Ignition temperature of gas or vapour in °C	Allowable temperature classes of equipment
T1	> 450	T1 – T6
T2	> 300	T2 – T6
T3	> 200	T3 – T6
T4	> 135	T4 – T6
T5	> 100	T5 – T6
T6	> 85	T6

5.6.3 Dust

5.6.3.1 General

Dust layers exhibit two properties as layer thickness increases: a reduction in minimum ignition temperature and an increase in thermal insulation.

The maximum permissible surface temperature for equipment is determined by the deduction of a safety margin from the minimum ignition temperature of the dust concerned, when tested in accordance with the methods specified in IEC 61241-2-1 (ISO/IEC 80079-20-2, under consideration) for both, dust cloud and layer.

For installations where the layer thickness is greater than 5 mm, the maximum surface temperature shall be determined with particular reference to the layer thickness and all the characteristics of the material(s) being used. Examples of excessively thick dust layers can be found in Annex L.

5.6.3.2 Temperature limitations because of the presence of dust clouds

The maximum surface temperature of equipment when tested in the dust-free test method in accordance with IEC 60079-0 shall not exceed two-thirds of the minimum ignition temperature in degrees Celsius of the dust/air mixture concerned:

$$T_{\text{max}} \leq 2/3\ T_{\text{CL}}$$

where T_{CL} is the minimum ignition temperature of the cloud of dust.

5.6.3.3 Temperature limitation because of presence of dust layers

Where the equipment is not marked with a dust layer thickness as part of the T rating, a safety factor shall be applied taking the dust layer thickness into account as:

– up to 5 mm thickness:

The maximum surface temperature of the equipment when tested in the dust-free test method in accordance with IEC 60079-0 shall not exceed a value of 75 °C below the minimum ignition temperature for the 5 mm layer thickness of the dust concerned:

$$T_{\text{max}} \leq T_{5\text{ mm}} - 75\ °\text{C}$$

where $T_{5\text{ mm}}$ is the minimum ignition temperature of the 5 mm layer of dust.

– above 5 mm up to 50 mm thickness:

Where there is a possibility that dust layers in excess of 5 mm may be formed on equipment, the maximum permissible surface temperature shall be reduced. For guidance, examples of the reduction in maximum permissible surface temperature of equipment used in the presence of dust having minimum ignition temperatures in excess of 250 °C for a 5 mm layer are shown in the graph below (Figure 1) for increasing depth of layers.

– For dust layers above 50 mm, see 5.6.3.4

Before applying the information in Figure 1, reference should be made to IEC 61241-2-1.

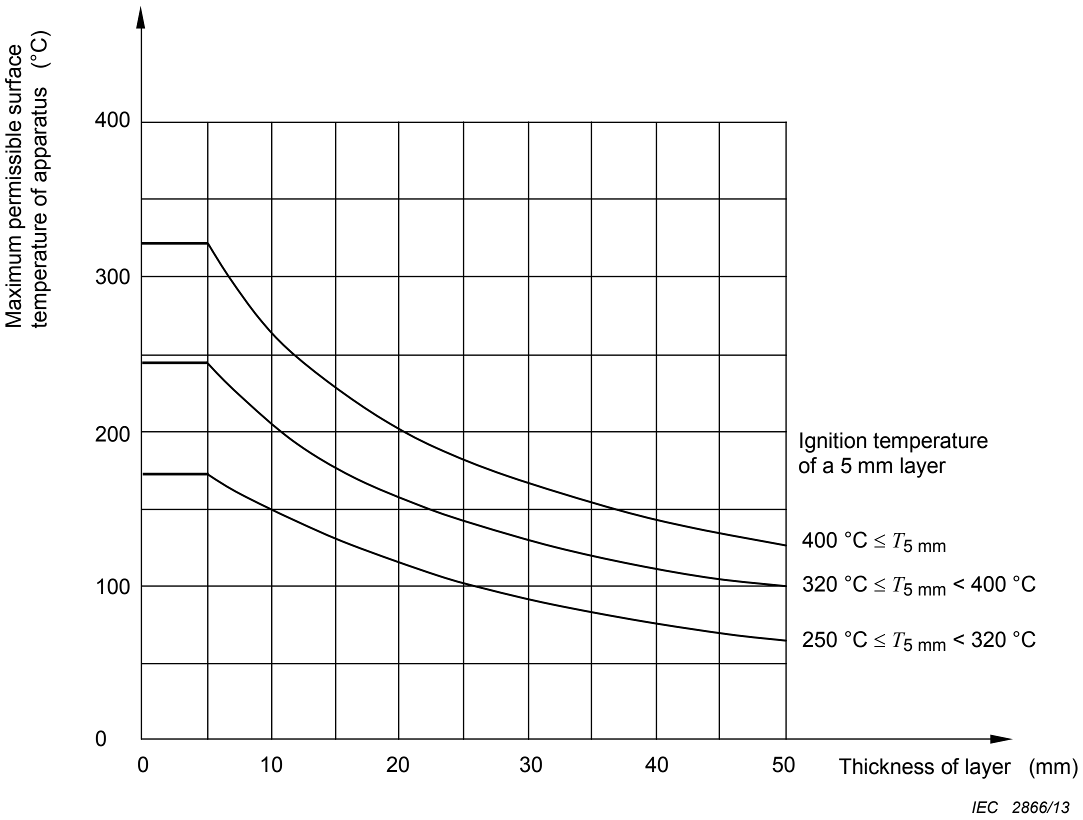

Figure 1 – Correlation between the maximum permissible surface temperature and depth of dust layers

Laboratory verification shall be carried out for equipment where the ignition temperature of a 5 mm layer is below 250 °C, or where there is any doubt concerning the application of the graph (see 5.6.3.4).

5.6.3.4 Unavoidable dust layers

Where it cannot be avoided that a dust layer forms around the sides and bottom of equipment, or where equipment is totally submerged in dust, because of the insulation effect a much lower surface temperature may be necessary. If equipment protection level “Da” is required in such situations, all specific requirements for EPL “Da” shall be fulfilled.

For installations where the layer depth is greater than 50 mm, the maximum surface temperature of equipment may be marked with the maximum surface temperature T_L as reference to the permitted layer depth. Where the equipment is marked T_L for a layer depth, the ignition temperature of the dust, at layer depth L, shall be applied in place of $T_{5\ mm}$. The maximum surface temperature of the equipment T_L shall be at least 75 °C lower than the ignition temperature of the dust, at layer depth L. Examples of excessively thick dust layers can be found in Annex L.

5.7 Selection of radiating equipment

5.7.1 General

The output parameters of lasers or other continuous wave sources of electrical equipment of EPL “Ga”, “Da”, “Gb” or “Db” shall not exceed the following values:

– 5 mW/mm^2 or 35 mW for continuous wave lasers and other continuous wave sources, and
– 0,1 mJ/mm^2 for pulse lasers or pulse light sources with pulse intervals of at least 5 s.

The output parameters of lasers or other continuous wave sources of electrical equipment of EPL “Gc” or “Dc” shall not exceed the following values:

– 10 mW/mm^2 or 35 mW for continuous wave lasers and other continuous wave sources, and
– 0,5 mJ/mm^2 for pulse lasers or pulse light sources.

NOTE 1 Radiation sources with pulse intervals of less than 5 s are regarded as continuous wave sources.

NOTE 2 These values are from IEC 60079-0.

For equipment installed outside, but radiating into the hazardous area, the requirements of 5.7.1 shall be applied.

For equipment located outside of a hazardous area, or certified to an edition of IEC 60079-0 or IEC 60079-28 where this requirement is not specified, these values may be confirmed by the equipment manufacturer.

5.7.2 Ignition process

Radiation in the optical spectral range, especially in the case of focusing, can become a source of ignition.

Sunlight, for example, may initiate an ignition if objects concentrate the radiation (for example, concave mirror, lenses, etc.).

The radiation from high intensity light sources, e.g. photo flash lamps or some LEDs is, in certain circumstances, absorbed by particles, such that these particles may become an ignition source.

NOTE Lighting equipment with divergent continuous light sources is normally considered to be not a hazard.

In the case of laser radiation (for example, signalling, telemeters, surveying, range-finders) the energy or power density even of the unfocused beam at long distances may be so great that ignition is possible. Here, too, the heating is mainly caused by the effect of the laser beam on dust layers or by absorption in particles in the atmosphere. Particularly intense focusing may cause temperatures far in excess of 1 000 °C at the focal point.

Consideration shall be given to the possibility that the equipment itself producing the radiation (for example, lamps, electric arcs, lasers, etc.) may be an ignition source.

5.8 Selection of ultrasonic equipment

5.8.1 General

For equipment installed in hazardous area, or installed outside, but radiating into the hazardous area, the output parameters from ultrasonic sources of electrical equipment of EPL “Ga”, “Gb”, “Gc”, “Da”, “Db”, or “Dc” shall not exceed the following values:

- 0,1 W/cm^2 and 10 MHz for continuous sources,
- average power density 0,1 W/cm^2 and 2 mJ/cm^2 for pulse sources.

NOTE These values are from IEC 60079-0.

For equipment located outside of a hazardous area, or certified to an edition of IEC 60079-0 where this requirement is not specified, these values may be confirmed by the equipment manufacturer.

5.8.2 Ignition process

When ultrasonics are applied, large proportions of the energy released by the sound transducer are absorbed by solid or liquid materials. Heating can occur in the material affected and, in extreme cases, may heat the material beyond the minimum ignition temperature.

5.9 Selection to cover external influences

Electrical equipment shall be selected and/or installed so that it is protected against external influences which could adversely affect the explosion protection. Some examples are:

– extremely low or high temperatures;
– solar radiation;
– pressure conditions;
– corrosive atmosphere;
– vibrations, mechanical impacts, friction or abrasion;
– wind;
– painting processes;
– chemicals;
– water and moisture;
– dust;
– plants, animals, insects.

External influences shall be identified as part of the installation design and selection of equipment for the installation and measures applied for control shall be documented and included in the verification dossier.

NOTE 1 Further information can be found in IEC 60364-5-51.

Where equipment is subject to prolonged humidity and wide temperature variations that may lead to condensation affecting the type of protection the equipment should be provided with suitable measures to ensure satisfactory prevention of condensation or draining of any condensate.

Precautions shall be taken, without affecting designed ventilation conditions, to prevent foreign bodies falling vertically into the ventilation openings of vertical rotating electrical machines.

The integrity of electrical equipment may be affected if it is operated under temperature or pressure conditions outside those for which the equipment has been constructed. In these circumstances, further advice shall be sought (see also 5.6).

Where risks can arise from high pressure process fluids entering equipment, (e.g. pressure switches or canned electric motor pumps) under fault conditions, (e.g. a diaphragm or can failure), the fluid may cause any or all of the following to occur:

– rupture of the equipment enclosure;
– risk of immediate ignition;
– transmission of the fluid along the inside of the cable or conduit.

Where equipment is at risk it should be selected so that process fluid containment is reliably separated from the electrical equipment (e.g. by use of a primary seal for the main process interface and a secondary seal internal to the equipment in case of primary seal failure). Where this is not achieved, the equipment should be vented (via a suitably explosion protected vent, drain or breather) and/or the wiring system shall be sealed to prevent the transmission of any fluid. Failure of the primary seal should also be annunciated e.g. by visible leak, self-revealing failure of the equipment, audible sound or electronic detection.

Potential wiring system sealing methods include: the use of a special sealing joint, or a cable gland incorporating a seal around the individual conductors, or a length of mineral-insulated metal-sheathed (MIMS) cable, or an "epoxy" joint should be introduced into the cable run. It should be noted that the application of a cable sealing device may only mitigate the rate of vapour transmission and additional attenuation measures may be necessary. Venting systems should be arranged so that the occurrence of any leaks will become apparent.

In the absence of IEC standards on process sealing for electrical equipment, national or other applicable standards such as IEC 61010-1 should be followed. IEC 61010-1 includes some information relative to process connections.

NOTE 2 IEC TS 60079-40 for process sealing is under consideration

When selecting enclosures with a higher degree of ingress protection (IP) than required by the type of protection (perhaps to make it suitable for an adverse environment), the IP rating of the enclosure should be maintained to the IP rating requirement of the location or that required by the type of protection whichever is the higher. Where the IP rating assigned to the equipment is not maintained, this should be identified in the verification dossier.

5.10 Selection of transportable, portable and personal equipment

5.10.1 General

Due to the demand of the application and enhanced flexibility for use, transportable, portable or personal equipment may be required to be used in differing areas. Equipment of a lower EPL shall not be taken into an area requiring a higher EPL, unless it is otherwise protected.

In practice, however, such a limitation may be difficult to enforce − particularly with portable or personal equipment. It is recommended, therefore, that all equipment meet the requirements of the location to which the equipment will be exposed which requires the highest EPL. Similarly, the equipment group and temperature classification should be appropriate for all the gases, vapours and dusts in which the equipment may be used.

Unless suitable precautions are taken, spare batteries shall not be taken into the hazardous area.

Where the equipment contains cells or batteries, the user shall verify with the manufacturer that the concentration of hydrogen in the free volume of the battery container or housing cannot exceed 2 % by volume, or the degassing apertures of all cells shall be so arranged that the escaping gases are not vented into any enclosure of the equipment containing electrical or electronic components or connections. Alternatively, where the equipment meets the requirements for Equipment Group IIC, the requirement of degassing apertures or limitation of hydrogen concentration does not apply.

NOTE 1 Due to the risk of gassing producing hydrogen from all cell types, provision for adequate venting is applied as the gassing can create an explosive condition in small enclosures. This condition would apply to torches, multi meters, pocket gas sensors and similar items.

NOTE 2 These details are derived from the requirements in IEC 60079-11.

5.10.2 Transportable and portable equipment

Unlike equipment which is permanently installed, transportable or portable equipment may occupy the hazardous area on a temporary basis. Such equipment may include, for example, emergency generators, electrical arc welders, industrial lift (fork) trucks, air compressors, powered ventilation fans or blowers, portable electrically powered hand-tools, certain types of test and inspection equipment.

Equipment that may be transported or carried into a hazardous area shall be to the appropriate equipment protection level. Where there is a need to use transportable or portable equipment in a hazardous area for which the normally required EPL is not obtainable, a documented program for risk management shall be implemented. This program shall include appropriate training, procedures and controls. A safe work permit shall be issued appropriate to the potential ignition risk created by the use of the equipment (see Annex B).

If plugs and sockets are present in a hazardous area, they shall be to the required EPL for the area. Alternately, they shall only be energized or connections made under a safe work procedure (see Annex B).

5.10.3 Personal equipment

Items of personal equipment which are battery or solar operated are sometimes carried by personnel and inadvertently taken into a hazardous area.

A basic electronic wrist watch is an example of a low voltage, electronic device which has been independently evaluated and found to be acceptable for use in a hazardous area under both historic and current EPL requirements.

All other personal battery or solar operated equipment (including electronic wrist watches incorporating other devices) shall:

a) conform to a recognised type of protection appropriate to EPL, gas/dust group and temperature class requirements, or
b) be subjected to a risk assessment, or
c) be taken into the hazardous area under a safe work procedure.

NOTE An increased risk is associated with lithium batteries which may be used to power personal electronic equipment.

5.11 Rotating electrical machines

5.11.1 General

In selecting rotating electrical machines, in addition to the requirements of 5.1 to 5.10, the following shall, as a minimum, be considered:

– duty type (S1 to S10 as defined in IEC 60034-1);
– supply voltage and frequency range;
– heat transfer from driven equipment (e.g. pump);
– bearing and lubricant life;
– insulation class

Motors which are subject to vibration and other factors which may affect cable connections and cable entry integrity should have additional care taken for:

– terminal screws and nuts which should be checked as securely tight to avoid excessive heat due to poor connections;
– glands and the parts used for the cable strain relief are tight to avoid stress on cable connections and maintain integrity of the gland.

5.11.2 Environmental Factors for "Ex" machine installation

Motors and generators require large volumes of clean air for cooling and the environmental factors which affect cooling shall be considered. These environmental factors include:

- a clean, well-ventilated location;
- the machine enclosure should be consistent with the location, environment and ambient conditions;
- if the location is not relatively free of dust and particles, the machine should have air filters or, in more severe cases, the machine should be enclosed;
- other equipment, walls, buildings, etc. should not restrict machine ventilation or allow ventilating air to recirculate:
  - adequate space around the machine for normal maintenance;
  - adequate overhead space for removal of the top cover;
  - an environment free of corrosive gases and liquids (both acids and bases).

Extreme care is required for machines supplied with a dust-ignition-proof collector-ring housing, accessory device, or conduit box since any nicks or burrs during disassembly and reassembly may destroy the explosion-proof or dust-ignition-proof features.

5.11.3 Power and accessory connections, grounding

The relevant installation and operating instructions as well as national and international rules have to be observed. Connection shall only be made by an expert and in accordance with the valid safety regulations. The power connections shall be in accordance with the manufacturer instructions with respect to:

- the electrical power: observe data on the rating plate; compare type of current, mains voltage and frequency; observe rated current for setting of the protective switch; connect motor in accordance with the wiring diagram provided in the terminal box; cable size dimensioned depending on the nominal current, cable length and ambient temperature;
- The type of protection of the cable gland, compliance with the allowable maximum temperature of the cable;
- the grounding conditions of the net. For earthing the motor is provided with an earthing terminal, which depending on the mounting arrangement is either located on the frame respectively on the flange end shield. In addition all motors have a protective conductor terminal inside the terminal box.

Depending upon the specific electric machine specified, according the outline nameplate, the machine may include any of the following accessories:

- stator winding resistance temperature detectors (slot detectors, HV);
- embedded temperature sensors in the winding system (LV);
- bearing temperature detectors, options: resistance or thermocouples, readout capability, alarm and shutdown contact capability;
- space heaters with their own temperature class;
- vibration sensors;
- tachometer;
- additional heaters for the bearing oil reservoir;
- controls for excess pressure drop across air filters.

The additional equipment has to fulfil its own requirements with possibly different types of protections, temperature classes or gas/dust groups.

As protection against dust and humidity, unused cable entries in the terminal box shall be sealed with a blanking element in accordance with the IEC 60079 series and shall have a torsion proof seal. All terminal screws and nuts have to be securely tightened to avoid excessive transition resistances. After entry of the cable into the terminal box the glands and the parts used for the strain relief are to be tightened with the corresponding torque in accordance with the data of the cable gland manufacturer.

5.11.4 Motors fed from a converter supply

Selection and installation of motors supplied at varying frequency and voltage by a converter shall take into account items that may reduce the voltage at the motor terminals. Also other hazards shall be taken into account.

NOTE 1 A filter at the output of the converter can cause a voltage drop at the terminals of the motor. The reduced voltage increases the motor current and slip, and therewith increases the temperature of the motor in the stator and rotor. Such temperature rise is most notable at constant rated load conditions.

NOTE 2 Additional information on the application of motors with a converter supply can be found in IEC/TS 60034-17 and IEC/TS 60034-25. Major concerns include frequency spectrums of the voltage and current plus their additional losses, over-voltage effects, bearing currents and high frequency earthing.

5.11.5 Switching motors above 1kV

5.11.5.1 General

Switching overvoltages can occur if vacuum circuit breakers or vacuum contactors are used, and switching transients known as multiple restrikes can occur when the high voltage motor is switched off. These transients depend on various installations system and design factors, such as:

– arc-extinguishing principle of the contactor or switch;
– size of the motor;
– length of the power supply cable;
– system capacitance, and other factors.

In some cases, multiple restrikes can result in switching overvoltages which are too high for the insulation of the motor stator winding leading to insulation deterioration and incendive sparks. In practice, this generally occurs when high-voltage motors with starting currents $I_A > 600$ A are disconnected during startup or during a stalled or overload condition.

Vacuum circuit breakers or vacuum contactors are commonly associated with high voltage transients. Surge suppressors should be installed in the switchgear, between the circuit breaker and the motor cable termination, for each of the three conductors to ground.

The peak voltages which arise as a result can damage the winding insulation, which can lead to insulation deterioration and incendive sparks. If vacuum circuit breakers or vacuum contactors are used for motor switching, the motor installation design should consider using an appropriate surge suppressor, such as a zinc oxide varistor with spark gap.

NOTE This starting current limit corresponds to the following upper power limits, depending on the relationship between the starting current I_A and rated current I_N and on the voltage dip (up to approximately 20 %) while the motor is starting up:

approximately 750 kW for motors supplied at up to 3,0 kV;
approximately 1 500 kW for motors supplied at up to 6,0 kV;
approximately 2 500 kW for motors supplied at up to 10,0 kV.

5.11.5.2 Overvoltages resulting from switching operations

Regardless of the motor size and the arc-extinguishing principle of the switch being used (i.e., even in the case of oil-free, SF_6 or air break switches), the following should be kept in mind when commissioning high-voltage motors/switchgear for high-voltage motors from 3 kV to 13,8 kV.

Shutting down the motor during startup can cause overvoltages. This can damage the motor and cause incendive sparks inside the motor enclosure and main terminal box. Precautions should be taken to avoid shutting down the motor during startup, for instance, it should be checked for errors in the starting control or for excessively sensitive protection settings. Shutdowns during startup, for checking the direction of rotation or other tests should be kept to an absolute minimum.

5.12 Luminaires

Selection of luminaires shall take into account the possibility of changes of the temperature class, if lamps with different wattages can be used.

Some luminaires will have different temperature classes according to the type or rating of the lamp used. The type or rating of the lamp used shall be selected according to the temperature class required.

If luminaires with replaceable lamps are selected, those shall be of a type using only unmodified standard lamps without supplemental fittings.

Low-pressure sodium lamps shall not be transported unprotected through a hazardous area owing to the risk of ignition due to free sodium from a broken lamp.

NOTE During the aging process some lamps can create hotspots (e.g. fluorescent lamps type HO), becoming a source of ignition.

5.13 Plugs and socket outlets

5.13.1 General

Plugs and socket outlets are not permitted in locations requiring EPL “Ga” and “Da”.

NOTE Connectors used for Ex “i” protection are not classified as plugs and socket outlets.

5.13.2 Specific requirements for explosive dust atmospheres

Socket outlets in areas requiring EPL “Db” and “Dc” shall be installed so that dust will not enter the socket outlet with or without a plug in place. To minimize the ingress of dust in the event of a dust cap being accidentally left off, socket outlets shall be positioned at an angle, which is not more than 60° to the vertical, and the opening facing downwards.

If couplers are used in areas endangered by explosive dust atmospheres, care should be taken that no dust will enter the coupler when disconnected.

5.13.3 Location

Socket outlets shall be installed in locations so that the flexible cord required shall be as short as possible in order to fulfil the disconnection time in the event of a fault as required in IEC 60364-4-41.

5.14 Cells and batteries

5.14.1 Charging of secondary cells and batteries

Cells and batteries shall only be recharged in a non-hazardous area, unless this is covered by the certificate and manufacturer’s instructions permit charging in a hazardous area.

NOTE 1 This includes charging of cells inside Ex “d” enclosures.

Before equipment is taken back into the hazardous are It shall be ensured that:

- the temperature is below the marked temperature class, and,

- no gas produced during charging is still in the container.

NOTE 2 Battery rooms are normally considered to be a safe area if in compliance with the relevant national or regional standards, (e.g. IEC 62485-2).

5.14.2 Ventilation

If there are openings in the enclosure required for ventilation of batteries, it shall be ensured that openings are not affected by the installation.

5.15 RFID tags

5.15.1 General

RFID tags shall not be used in environments with high electromagnetic fields exceeding RMS values of 1 A/m or 3 V/m e.g. in high current electrolysis plants.

5.15.2 Passive RFID tags

Passive RFID tags, i.e. tags, which are not battery powered and derive power from the RF reader only, need not be certified if their construction meets the requirements for simple apparatus.

Passive RFID tags shall be considered to have a temperature class T6 at an ambient temperature $T_{amb} \leq 40$ °C, or temperature class T5 at an ambient temperature $T_{amb} \leq 60$ °C, if not specified by the manufacturer.

5.15.3 Mounting RFID tags

The tag housing shall comply with the requirements in 6.5.

In locations requiring EPL “Ga” or “Da”, RFIDs shall only be used if certified together with the equipment.

In locations requiring EPL “Gb” or “Db” a special precaution shall be applied to prevent foreseeable failures (e.g. dropping the tag), to avoid reducing creepage and clearance distances of other devices.

Mounting of a tag shall not impair the properties of the tag itself, nor shall the type of protection of the equipment, on which it is attached, be affected negatively.

When using adhesives the maximum operating temperature has to be considered.

Creepage and clearance distances shall not be affected by mounting. Damaged RFID tags shall not be taken into a hazardous area.

5.16 Gas detection equipment

Gas detection may be used as a part of control measures to enable the use of electrical equipment in hazardous areas where that equipment might not meet other requirements of this standard. (see 4.1)

For gas detection equipment, all relevant requirements in IEC 60079-29-1 to IEC 60079-29-4 shall be applied.

6 Protection from dangerous (incendive) sparking

6.1 Light metals as construction materials

The material composition of metallic installation materials (e.g. cable trays, mounting plates, weather protection and enclosures) shall comply with the following requirements. Materials used in Group II installations for the identified equipment protection levels shall not contain, by mass, more than:

- for EPL "Ga"

  10 % in total of aluminium, magnesium, titanium and zirconium, and

  7,5 % in total of magnesium, titanium and zirconium;
- for EPL "Gb"

  7,5 % in total of magnesium, titanium and zirconium;
- for EPL "Gc"

  no requirements.

Materials used in Group III installations for the identified equipment protection levels shall not contain, by mass, more than:

- for EPL "Da"

  7,5 % in total of magnesium, titanium and zirconium;
- for EPL "Db"

  7,5 % in total of magnesium, titanium and zirconium;
- for EPL "Dc"

  no requirements

Particular consideration shall be given to the location of items that incorporate light metals in the external construction as it has been well established that such materials give rise to sparking that is incendive under conditions of frictional contact.

NOTE These values are taken from IEC 60079-0 for equipment.

6.2 Danger from live parts

In order to avoid the formation of sparks liable to ignite the explosive atmosphere, the possible inadvertent contact with bare live parts other than single intrinsically safe or energy-limited parts shall be prevented.

NOTE When more than one intrinsically safe circuit can be contacted at the same time the resultant spark may be ignition capable.

6.3 Danger from exposed and extraneous conductive parts

6.3.1 General

The limitation of earth-fault currents (magnitude and/or duration) in frameworks or enclosures and the prevention of elevated potentials on equipotential bonding conductors are essential for safety.

Although it is impracticable to cover all possible systems, the following applies to electrical systems, other than intrinsically safe or energy-limited circuits with voltages up to 1 000 V a.c. r.m.s./1 500 V d.c.

6.3.2 TN type of system earthing

If a type of system earthing TN is used, it shall be type TN-S (with separate neutral N and protective conductor PE) in the hazardous area, i.e. the neutral and the protective conductor shall not be connected together, or combined in a single conductor, in the hazardous area. At any point of transition from TN-C to TN-S, the protective conductor shall be connected to the equipotential bonding system in the non-hazardous area.

6.3.3 TT type of system earthing

If a type of system earthing TT (separate earths for power system and exposed conductive parts) is used, then it shall be protected by a residual current device.

NOTE Where the earth resistivity is high, such a system may not be acceptable.

6.3.4 IT type of system earthing

If a type of system earthing IT (neutral isolated from earth or earthed through an sufficiently high impedance) is used, an insulation monitoring device shall be provided to indicate the first earth fault.

NOTE 1 If the first fault is not removed, a subsequent fault on the same phase will not be detected, possibly leading to a dangerous situation.

NOTE 2 Local bonding, known as supplementary equipotential bonding, can be necessary (see IEC 60364-4-41).

6.3.5 SELV and PELV systems

Safety extra-low voltage systems (SELV) shall be in accordance with 414 of IEC 60364-4-41:2005. Live parts of SELV circuits shall not be connected to earth, or to live parts or to protective conductors forming part of other circuits. Any exposed conductive parts may be unearthed or earthed (for example for electro-magnetic compatibility).

Protective extra-low voltages systems (PELV) shall be in accordance with 414 of IEC 60364-4-41:2005. PELV circuits are earthed. Any exposed conductive parts shall be connected to a common earthing (and potential equalization) system.

Safety isolating transformers for SELV and PELV shall be in accordance with IEC 61558-2-6.

6.3.6 Electrical separation

Electrical separation shall be in accordance with 413 of IEC 60364-4-41:2005 for the supply of only one item of equipment.

6.3.7 Non Ex electrical equipment above hazardous areas

Special consideration shall be given to situations when non Ex equipment and connecting electrical circuits that may become a source of ignition, or may produce hot particles or hot surfaces are located above a hazardous area. Such equipment shall be either totally enclosed or provided with suitable guards or screens, to prevent it or hot particles from falling into the hazardous area.

A risk assessment shall take into account a possibility of such equipment or its parts, including connecting electrical circuits, falling into the hazardous area and creating a source of ignition due to a damage or fault.

NOTE Such items include:

- fuses that can produce arcs, sparks or hot particles;
- switches, plugs and sockets, that may produce arcs, sparks or hot particles;
- motors or generators that have sliding contacts or brushes;

- heaters, heating elements or other equipment that may produce arcs, sparks or hot particles;
- auxiliary equipment such as ballasts, capacitors and starting switches for all types of discharge luminaires;
- all exposed lamps;
- all unsupported cables.

Low pressure sodium vapour discharge lamps shall not be installed above a hazardous area.

6.4 Potential equalization

6.4.1 General

Potential equalization is required for installations in hazardous areas. For TN, TT and IT systems, all exposed and extraneous conductive parts shall be connected to the equipotential bonding system. The bonding system may include protective conductors, metal conduits, metal cable sheaths, steel wire armouring and metallic parts of structures, but shall not include neutral conductors. Connections shall be secure against self loosening and shall minimise the risk of corrosion which may reduce the effectiveness of connection.

An internal earth continuity plate may be fitted, for example, to allow for use of metallic cable glands without the use of separate individual earthing tags. The material and dimensions of the earth continuity plate should be appropriate for the anticipated fault current.

If the armour or screens of cables are only earthed outside the hazardous area (e.g. in the control room) then this point of earthing shall be included in the potential equalization system of the hazardous area.

If the armour or screen is earthed only outside of the hazardous area in TN system there is a possibility, that dangerous sparks may be created at the ending of the armour or screen in the hazardous area. Therefore, this armour or screen should be treated like unused cores (see 9.6.3).

Exposed conductive parts need not be separately connected to the equipotential bonding system if they are firmly secured to and are in conductive contact with structural parts or piping which are connected to the equipotential bonding system. Extraneous conductive parts which are not part of the structure or of the electrical installation, for example frames of doors or windows, need not be connected to the equipotential bonding system, if there is no danger of voltage displacement.

Cable glands which incorporate clamping devices which clamp the braiding or armour of the cable can be used to provide equipotential bonding.

The minimum size for bonding conductors for the main connection to a protective rail shall be 6 mm^2 and supplementary connections shall be a minimum of 4 mm^2. Consideration should also be given to using larger conductors for mechanical strength.

Metallic enclosures of intrinsically safe or energy-limited apparatus need not be connected to the equipotential bonding system, unless required by the equipment documentation or to prevent accumulation of static charge.

Installations with cathodic protection shall not be connected to the equipotential bonding system unless the system is specifically designed for this purpose.

Potential equalization between vehicles and fixed installations may require special arrangements, for example where insulated flanges are used to connect pipelines.

6.4.2 Temporary bonding

Temporary bonding includes earth connections that are made to moveable items such as drums, vehicles and portable equipment for control of static electricity or potential equalisation.

It is recommended that the final connection of a temporary bonding connection should be made either:

- in a non-hazardous area; or
- using a connection that meets the EPL requirements of the location; or
- using a documented procedure which reduces the risk of sparking to an acceptable level.

For temporary bonding the resistance between metallic parts shall be less than 1 MΩ. This shall be ensured either by measuring or by monitoring of the value. Conductors and connections shall be durable, flexible and of sufficient mechanical strength to withstand in-service movement. Mechanical strength of the conductor shall be equivalent to at least 4 mm^2 copper, or be part of a flexible cabling system incorporating a monitoring and control system.

Consideration should be given to the use of a permanent monitoring system to demonstrate that the connection system is always below 1 MΩ.

6.5 Static electricity

6.5.1 General

The requirements of 6.5.1 apply to external non-metallic materials used for construction or protecting purposes that are not part of certified equipment (e.g. plastic covered cable tray, plastic mounting plates, plastic weather protection and enclosures).

NOTE 1 Non-metallic paints, films, foils, and plates are typically attached to external surfaces of metallic parts to provide additional environmental protection. Their ability to store an electrostatic charge is addressed by 6.5.

NOTE 2 It is generally acknowledged that glass is not susceptible to storing an electrostatic charge.

NOTE 3 Further information can be found in IEC TS 60079-32-1 and IEC 60079-32-2 (under consideration).

6.5.2 Avoidance of a build-up of electrostatic charge on construction and protecting parts for locations requiring EPL “Ga”, “Gb” and “Gc”

Construction and protecting parts shall be so designed that under normal conditions of use, maintenance and cleaning, danger of ignition due to electrostatic charges is avoided. This requirement shall be satisfied by one of the following:

a) By suitable selection of the material so that maximum surface resistance complies with either of the limits given below when measured in accordance with IEC 60079-0:
   - 10^9 Ω measured at (50 ± 5) % relative humidity; or
   - 10^{11}Ω measured at (30 ± 5) % relative humidity.

b) By limitation of the surface area of non-metallic parts as shown in Table 5.

   The surface area is defined as follows:
   - for sheet materials, the area shall be the exposed (chargeable) area;
   - for curved objects, the area shall be the projection of the object giving the maximum area;
   - for individual non-metallic parts, the area shall be evaluated independently if they are separated by conductive earthed frames.

   The values for surface area can be increased by a factor of four if the exposed area of non-metallic material is surrounded by and in contact with conductive earthed frames.

Alternatively, for long parts with non-metallic surfaces, such as tubes, bars, or ropes, the surface area need not be considered, but the diameters or widths shall not exceed the values shown in Table 6. Cables for connection of external circuits are not considered to fall under this requirement.

c) By limitation of a non-metallic layer bonded to a conductive surface. The thickness of the non-metallic layer shall not exceed the values shown in Table 7 or the breakdown voltage shall be ≤ 4 kV (measured across the thickness of the insulating material according to the method described in IEC 60243-1).

d) Where the construction and protecting parts are used in the installation in such a way that the risk from electrostatic discharge is minimized, these parts shall be marked with the following warning label:

WARNING – POTENTIAL ELECTROSTATIC CHARGING HAZARD

Table 5 – Limitation of surface areas

Construction and protecting parts (mm^2)			
Equipment protection level required	**Group IIA**	**Group IIB**	**Group IIC**
EPL Ga	5 000	2 500	400
EPL Gb	10 000	10 000	2 000
EPL Gc	10 000	10 000	2 000

Table 6 – Maximum diameter or width

Construction and protecting parts (mm)			
Equipment protection level required	**Group IIA**	**Group IIB**	**Group IIC**
EPL Ga	3	3	1
EPL Gb	30	30	20
EPL Gc	30	30	20

Table 7 – Limitation of thickness of non-metallic layer

Construction and protecting parts (mm)			
Equipment protection level required	**Group IIA**	**Group IIB**	**Group IIC**
EPL Ga	2	2	0,2
EPL Gb	2	2	0,2
EPL Gc	2	2	0,2
These thickness limitations do not apply to non-metallic layers that have a surface resistance of less than 10^9 Ω or 10^{11} Ω, as applicable. See IEC 60079-0. One of main reasons for the thickness limitation is that the maximum thickness of non-metallic layer is intended to permit dissipation of charge through the insulation to earth. By this means the static charge is not able to build up to incendive levels.			

6.5.3 Avoidance of a build-up of electrostatic charge on construction and protecting parts for locations requiring EPL “Da”, “Db” and “Dc”

Painted/coated metal and plastic construction and protecting parts shall be so designed that under normal conditions of use, danger of ignition due to propagating brush discharges is avoided.

If plastic with a surface area exceeding 500 mm^2 is employed as a covering on a conductive material, the plastic shall have one or more of the following characteristics:

a) by suitable selection of the material so that surface resistance complies with the limits given in IEC 60079-0;
b) a breakdown voltage ≤ 4 kV (measured across the thickness of the insulating material according to the method described in IEC 60243-1);
c) where the construction and protecting parts are used in the installation in such a way that the risk from electrostatic discharge is minimized, these parts shall be marked with the following warning label:

   WARNING – POTENTIAL ELECTROSTATIC CHARGING HAZARD

Cable routing shall be arranged so that the cables are not exposed to the friction effects and static build-up due to the passage of dust. Precautions shall be taken to prevent the build-up of static on surfaces of cables.

6.6 Lightning protection

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of lightning (see IEC 62305-3:2010, Annex D).

Subclause 16.3 gives details of lightning protection requirements for Ex “ia” apparatus installed in locations requiring EPL “Ga”.

6.7 Electromagnetic radiation

6.7.1 General

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of electromagnetic radiation.

6.7.2 Radio frequency received in hazardous areas

Structures and antennas located in hazardous areas can act as receivers for transmissions from outside of the hazardous area. The threshold power of radio frequency (9 kHz to 60 GHz) received in the hazardous area for continuous transmissions and for pulsed transmissions whose pulse durations exceed the thermal initiation time shall not exceed the values shown in Table 8 - Radio frequency power thresholds. Programmable or software control intended for setting by the user shall not be permitted.

NOTE 1 The values in Table 8 would be of concern for high power transmitters located close to a hazardous area. Additional information on the application of higher power radiating sources for normal commercial signals at a distance from the plant can be found, in CLC/TR 50427. The results of the TR are based on far field conditions.

Table 8 – Radio frequency power thresholds

Equipment for	Threshold power W	Thermal initiation time μs
Group IIA	6	100
Group IIB	3,5	80
Group IIC	2	20
Group III	6	200

For pulsed radar and other transmissions where the pulses are short compared with the thermal initiation time, the threshold energy values Z_{th} shall not exceed those given in Table 9.

Table 9 – Radio-frequency energy thresholds

Equipment for	Threshold energy Z_{th} μJ
Group IIA	950
Group IIB	250
Group IIC	50
Group III	1 500

NOTE 2 In Tables 8 and 9, the same values are applied for “Ga”, “Gb”, “Gc”, “Da”, “Db”, or “Dc” equipment due to the large safety factors involved.

NOTE 3 In Tables 8 and 9, the values apply in normal operation, provided that the user of the equipment does not have access to adjust the equipment to give higher values.

NOTE 4 These requirements are derived from IEC 60079-0.

6.8 Cathodically protected metallic parts

Cathodically protected metallic parts located in hazardous areas are live extraneous conductive parts which shall be considered potentially dangerous (especially if equipped with an impressed current system) despite their low negative potential. No cathodic protection shall be provided for metallic parts in locations requiring EPL “Ga” or “Da” unless it is specially designed for this application.

The insulating elements required for the cathodic protection, for example insulating elements in pipes and tracks, should if possible be located outside the hazardous area.

In the absence of IEC standards on cathodic protection, national or other standards should be followed.

6.9 Ignition by optical radiation

In the design of optical installations, steps shall be taken to reduce to a safe level the effects of radiation in accordance with 5.7.

NOTE Optical equipment in the form of lamps, lasers, LEDs, optical fibers etc. is increasingly used for communications, surveying, sensing and measurement. In material processing optical radiation of high irradiance is used. Often the installation is inside or close to explosive atmospheres and radiation from such equipment can pass through these atmospheres. Depending on the characteristics of the radiation it might then be able to ignite a surrounding explosive atmosphere. The presence or absence of an additional absorber significantly influences the ignition.

7 Electrical protection

The requirements of Clause 7 are not applicable to intrinsically safe and energy-limited circuits.

Electrical circuits and equipment shall be protected against the dangerous effects of short-circuits, overloads and earth faults. Protection devices shall be such that auto-reclosing under fault conditions is prevented.

Lower values of disconnection time than those stated in IEC 60364-4-41 may be required for installations in areas requiring EPL “Ga”, “Gb”, “Da” and “Db”.

Overload protection for electrical equipment is required if overload in use cannot be avoided.

Precautions shall be taken to prevent operation of polyphase electrical equipment where the loss of one or more phases can cause overheating to occur.

In circumstances where automatic disconnection of the electrical equipment may introduce a safety risk which is more dangerous than that arising from the risk of ignition alone, a warning alarm may be used as an alternative to automatic disconnection provided that operation of the warning alarm is immediately apparent so that prompt remedial action will be taken.

8 Switch-off and electrical isolation

8.1 General

The requirements of Clause 8 are not applicable to intrinsically safe and energy-limited circuits.

8.2 Switch-off

For functional or emergency purposes, at (a) suitable point(s), there shall be a means of switching off electrical supplies to the hazardous area.

Electrical equipment which should continue to operate to prevent additional danger shall not be included and shall be on (a) separate circuit(s).

NOTE The switching devices installed in the general switchgear are normally adequate with respect to switch-off facilities.

Switch off should consider isolation of all circuit power supply conductors including the neutral.

Suitable points for switch off should be assessed relevant to the site distribution, personnel on site and the nature of site operations.

8.3 Electrical isolation

A means of isolation shall be provided to isolate all live conductors, including the neutral, to allow electrical work to be carried out safely. Where all conductors are not isolated by the same device the means of isolation of other conductors shall be clearly identified.

The preferred means of isolation is by a device that operates in all relevant conductors at the same time. The means of isolation may include fuses and neutral links where relevant.

Labelling shall be provided immediately adjacent to each means of isolation to permit rapid identification of the circuit or group of circuits thereby controlled.

There shall be effective measures or procedures to prevent the restoration of supply to the equipment whilst the risk of exposing unprotected live conductors to an explosive atmosphere continues.

9 Cables and wiring systems

9.1 General

Cable and wiring systems shall comply with the relevant requirements of Clause 9.

9.2 Aluminium conductors

Where aluminium is used as the conductor material, it shall be used only with suitable connections and, with the exceptions of intrinsically safe and energy-limited installations, shall have a cross-sectional area of at least 16 mm^2.

Connections shall ensure that the required creepage and clearance distances will not be reduced by the additional means which are required for connecting aluminium conductors.

Minimum creepage and clearance distances may be determined by the voltage level and/or the requirements of the type of protection.

Precautions against electrolytic corrosion shall be considered.

9.3 Cables

9.3.1 General

Cables with low tensile strength sheaths (commonly known as “easy tear” cables) shall not be used in hazardous areas unless installed in conduit.

NOTE Cables, with sheaths of a tensile strength lower than

i) thermoplastic
   - polyvinyl chloride (PVC) 2,5 N/mm^2
   - polyethylene 15,0 N/mm^2

ii) elastomeric
   - polychloroprene, chlorosulfonated, polyethylene or similar polymers 15,0 N/mm^2

are commonly known as “easy tear” cables.

9.3.2 Cables for fixed installations

Cables used for fixed installations in hazardous areas shall be appropriate for the ambient conditions in service. Cables shall be:

a) sheathed with thermoplastic, thermosetting, or elastomeric material. They shall be circular and compact. Any bedding or sheath shall be extruded. Fillers, if any, shall be non-hygroscopic; or
b) mineral insulated metal sheathed; or
c) special, e.g. flat cables with appropriate cable glands. They shall be compact and any bedding or sheath shall be extruded. Fillers, if any, shall be non-hygroscopic.

Where there is a likelihood that gas or vapour migration may occur through the interstices between individual cores of a cable, and the cable leads to a non-hazardous area or between different zones, then the construction and application of the cable shall be taken into account. Appropriate control measures to mitigate this condition shall be considered (see Annex E).

Where there is a likelihood that propagation of flames may occur through the interstices between individual cores of a cable, this shall also be considered.

Mineral insulated cables shall be sealed.

NOTE These requirements do not cover the selection of equipment for process sealing.

9.3.3 Flexible cables for fixed installations (excluding intrinsically safe circuits)

Flexible cables in hazardous areas shall be selected from the following:

a) ordinary tough rubber sheathed;
b) ordinary polychloroprene sheathed;
c) heavy tough rubber sheathed;
d) heavy polychloroprene sheathed;
e) plastic insulated and of equally robust construction to heavy tough rubber sheathed flexible cables.

In the absence of IEC cable standards, reference should be made to national or other standards.

For connections to fixed equipment that may be required from time to time to be moved a small distance (e.g. motors on slide rails), cables should be arranged to permit the necessary movement without detriment to the cable. Either this, or one of the types of cables suitable for use with transportable equipment may be used. Suitably protected terminal boxes for the junction with the fixed wiring and the wiring to the equipment shall be provided where the fixed wiring is not itself of a type suitable to permit the necessary movement. If flexible tubing is used, it and its fittings shall be so constructed that damage to the cable consequent upon its use is avoided. Adequate earthing or bonding should be maintained; the flexible tubing should not be the sole means of earthing. The flexible tubing shall be impervious to dust and its use shall not impair the integrity of the enclosure of the equipment to which it is joined.

9.3.4 Flexible cables supplying transportable and portable equipment (excluding intrinsically safe circuits)

Transportable and portable electrical equipment shall have cables with a heavy polychloroprene or other equivalent synthetic elastomeric sheath, cables with a heavy tough rubber sheath, or cables having an equally robust construction. The conductors for the supply cable shall be stranded and shall have a minimum cross-sectional area of 1,0 mm^2. If a protective earthing (PE) conductor is necessary, it shall be separately insulated in a manner similar to the other conductors and shall be incorporated within the supply cable sheath.

If, for transportable and portable electrical equipment, a metallic flexible armour or screen is incorporated in the cable, this shall not be used as the only protective conductor. The cable shall be suitable for the circuit protective arrangements, e.g. where earth monitoring is used, the necessary number of conductors shall be included. Where the equipment needs to be earthed, the cable may include an earthed flexible metallic screen in addition to the PE conductor.

Portable electrical equipment with rated voltage not exceeding 250 V to earth and with rated current not exceeding 6 A may have cables:

– with an ordinary polychloroprene or other equivalent synthetic elastomeric sheath,
– with an ordinary tough rubber sheath, or
– with an equally robust construction.

These cables are not admissible for portable electrical equipment exposed to heavy mechanical stresses, for example hand-lamps, foot-switches, barrel pumps, etc.

9.3.5 Single insulated wires (excluding intrinsically safe circuits)

Single insulated wires shall not be used for live conductors, unless they are installed inside switchboards, enclosures or conduit systems.

9.3.6 Overhead lines

Where overhead wiring with uninsulated conductors provides power or communication services to a hazardous area, it shall be terminated in a non-hazardous area and the service continued into the hazardous area with cable or conduit.

Uninsulated conductors should not be installed above hazardous areas.

NOTE Uninsulated conductors include items such as partially insulated crane conductor rail systems and low and extra-low voltage track systems.

9.3.7 Avoidance of damage

Cable systems and accessories should be installed, so far as is practicable, in positions that will prevent them being exposed to mechanical damage, to corrosion or chemical influences (for example solvents), to the effects of heat and to the effects of UV radiation (but see also 16.2.2.5 for intrinsically safe circuits).

Where exposure of this nature is unavoidable, protective measures, such as installation in protecting conduit, shall be taken or appropriate cables selected (for example, to minimize the risk of mechanical damage, armoured, screened, seamless aluminium sheathed, mineral-insulated metal sheathed or semi-rigid sheathed cables could be used).

Where cables are subject to other conditions e.g. vibration or continuous flexing, they shall be designed to withstand that condition without damage.

Precautions should be taken to prevent damage to the sheathing or insulating materials of cables when they are to be installed at temperatures below –5 °C.

Where cables are secured to equipment or cable trays the bend radius on the cable should be in compliance with the cable manufacturer’s data or be at least 8 times the cable diameter to prevent damage to the cable. The bend radius of the cable should start at least 25 mm from the end of the cable gland.

9.3.8 Cable surface temperature

The surface temperature of cables shall not exceed the temperature class for the installation.

NOTE Where cables are identified as having a high operating temperature (for example 105 °C), this temperature relates to the copper temperature of the cable and not the cable sheath. Due to heat losses, it is unlikely that cable temperature will exceed T6.

9.3.9 Resistance to flame propagation

Cables for fixed installations shall have either:

a) flame propagation characteristics which enable them to withstand the tests according to IEC 60332-1-2 or IEC 60332-3-22 as appropriate (see NOTE);
b) other protection against flame propagation (e.g. laid in sand filled trenches); or
c) cables entering hazardous areas shall be installed with a barrier to prevent flame propagation from a non-hazardous area into a hazardous area.

NOTE IEC 60332-1-2 specifies the use of a 1 kW pre-mixed flame and is for general use, except that the procedure specified may not be suitable for the testing of small single insulated conductors or cables of less than 0,5 mm^2 total cross-section because the conductor melts before the test is completed, or for the testing of small optical fibre cables because the cable is broken before the test is completed. In these cases, the procedure given in IEC 60332-3-22 is used.

Since the use of insulated conductor or cable which retards flame propagation and complies with the recommended requirements of IEC 60332-1-2 is not sufficient by itself to prevent propagation of fire under all conditions of installation, it is recommended that wherever the risk of propagation is high, for example in long vertical runs of bunches of cables, special installation precautions should also be taken. It cannot be assumed that because the sample of cable complies with the performance requirements recommended in IEC 60332-1-2, a bunch of cables will behave in a similar manner. In such situations verification is possible by testing for vertical flame spread of vertically-mounted bunched wires or cables in accordance with the IEC 60332-3 series.

9.4 Conduit systems

The conduit shall be provided with a conduit sealing device where it enters or leaves a hazardous area, to prevent the transmission of gases or liquids from the hazardous areas to non-hazardous areas. There shall be no union, coupling or other fittings between the sealing device and the hazardous area’s boundary.

Conduit sealing devices shall seal around the outer sheath of the cable where the cable is effectively filled or around the individual conductors inside the conduit. The sealing mechanism shall be such that it does not shrink on setting and sealing mechanisms shall be impervious to, and unaffected by, chemicals found in the hazardous area.

If required to maintain the appropriate degree of ingress protection (e.g. IP54) of the enclosure, the conduit shall be provided with a conduit sealing device adjacent to the enclosure.

The conduit shall be wrench tight at all of the threaded connections.

Where the conduit system is used as the protective earthing conductor, the threaded junction shall be suitable to carry the fault current which would flow when the circuit is appropriately protected by fuses or circuit-breakers.

In the event that the conduit is installed in a corrosive area, the conduit material shall either be corrosion resistant or the conduit shall be adequately protected against corrosion.

Combinations of metals that can lead to galvanic corrosion shall be avoided.

Non-sheathed insulated single or multicore cables may be used in the conduits. However, when the conduit contains three or more cables, the total cross-sectional area of the cables, including insulation, shall be not more than 40 % of the cross-sectional area of the conduit.

Long runs of conduits shall be provided with suitable draining devices to ensure satisfactory draining of condensate. In addition, cable insulation shall have suitable water resistance.

To meet the degree of protection required by the enclosure, in addition to the use of conduit sealing devices, it may be necessary to seal between the conduit and the enclosure (for example by means of a sealing washer or non-setting grease).

Where the conduit is the sole means of earth continuity, this sealing shall not reduce the effectiveness of the earth path.

The conduit used for mechanical protection only (commonly referred to as “open” conduit systems) does not need to meet the requirements of 9.4. However, precaution measures shall be applied to prevent the transfer of potentially explosive atmosphere through the conduit with suitable conduit sealing devices where the conduit enters or leaves a hazardous area.

Where conduits are connected to a conduit entry device into an enclosure the connection of the conduit and conduit entry device shall maintain the integrity of the fitting, e.g. IP rating and mechanical integrity.

In addition, national or other standards should be followed for conduit systems.

9.5 Additional requirements

Additional requirements for cables and conduit systems are given in Clauses 14 to 23 for each type of protection.

Cables in conduits, and fittings for the appropriate protection technique and for the area in which they are to be installed, may be subject to approval at national level.

Additional requirements for cables and conduit systems used with other types of protection according to IEC 60079-26 shall comply with the relevant protection concepts identified in the documentation.

9.6 Installation requirements

9.6.1 Circuits traversing a hazardous area

Where circuits traverse a hazardous area in passing from one non-hazardous area to another, the wiring system in the hazardous area shall be appropriate to the EPL requirements for the route.

9.6.2 Terminations

Connections shall be made in a manner consistent with the type of terminal, type of protection and the manufacturer's instructions and not introduce undue stress on the connections.

If multi-stranded and, in particular, fine-stranded conductors are employed, the ends shall be protected against separation of the strands, for example by means of cable lugs or core end sleeves, or by the type of terminal, but not by soldering alone.

The creepage distances and clearances, in accordance with the type of protection of the equipment, shall not be reduced by the method in which the conductors are connected to the terminals.

9.6.3 Unused cores

The hazardous area end of each unused core in multi-core cables shall either be connected to earth or be adequately insulated by means of terminations suitable for the type of protection. Insulation by tape alone is not permitted.

Alternative requirements apply for unused cores in multicore cables of intrinsic safety and energy-limited circuits (see 16.2.2.5.3).

9.6.4 Openings in walls

Openings in walls for cables and conduits between different hazardous areas and between hazardous and non-hazardous areas shall be adequately sealed, for example by means of sand seals or mortar sealing to maintain the area classification where relevant.

9.6.5 Passage and collection of flammables

Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions shall be taken to prevent the passage of flammable gases, vapours or liquids from one area to another and to prevent the collection of flammable gases, vapours or liquids in trenches.

Such precautions may involve the sealing of trunking, ducts or pipes. For trenches, adequate venting or sand-filling may be used. Conduits and, in special cases, cables (e.g. where there is a pressure differential) shall be sealed, if necessary, so as to prevent the passage of liquids or gases. See also 9.3.1.

9.6.6 Accumulation of dust

Cable routing should be arranged in such a way that the cables accumulate the minimum amount of dust layers whilst remaining accessible for cleaning. Where trunking, ducts or pipes or trenches are used to accommodate cables, precautions should be taken to prevent the passage or collection of dusts in such places. Where layers of dust are liable to form on cables and impair the free circulation of air, consideration shall be given to derating the current-carrying capacity of the cables, especially if low minimum ignition temperature dusts are present.

10 Cable entry systems and blanking elements

10.1 General

If a cable gland is to be used at an ambient temperature range different from –20 °C to 40 °C and/or an operating temperature higher than 80 °C this shall be covered by certification documentation.

10.2 Selection of cable glands

The cable gland shall be selected to match the cable diameter. The use of sealing tape, heat shrink tube or other materials is not permitted to make the cable fit to the cable gland.

Cable glands and/or cables shall be selected to reduce the effects of “coldflow characteristics” of the cable.

NOTE 1 Cables employ materials which could exhibit “coldflow” characteristics. Coldflow in cables can be described as the movement of the cable sheath under the compressive forces created by the displacement of seals in cable glands where the compressive force applied by the seal is greater than the resistance of the cable sheath to deformation. Coldflow could give rise to a reduction in the insulation resistance of the cable. Low smoke and/or fire resistant cables usually exhibit significant cold flow characteristics.

Cable glands shall be in accordance with IEC 60079-0 and shall be selected to maintain the requirements of the protection technique according to Table 10.

Table 10 − Selection of glands, adapters and blanking elements type of protection according to the enclosure type of protection

Protection technique for the equipment	Glands, adapters and blanking element protection technique			
	Ex "d" see 10.6	**Ex "e"** see 10.4	**Ex "n"** see 10.4	**Ex "t"** see 10.7
Ex "d"	X			
Ex "e"	X	X		
Ex "i" and Ex "nL" – Group II[a]	X	X	X – see 16.5	
Ex "i" – Group III [a]				X – see 16.5
Ex "m"	Ex "m" would not normally be applied to wiring connections. The protection technique for connections shall suit the wiring system used.			
Ex "n" except Ex "nL" For Ex "nR" see also 10.8	X	X	X	
Ex "o"	Ex "o" would not normally be applied to wiring connections. The protection technique for connections shall suit the wiring system used			
Ex "p", all types	X	X	X [b]	
Ex "pD"				X
Ex "q"	Ex "q" would not normally be applied to wiring connections. The protection technique for connections shall suit the wiring system used.			
Ex "s"	Only as allowed by the conditions of the certificate.			
Ex "t"				X
X denotes permitted use. [a]If only one intrinsically safe circuit is applied then there are no specified requirements for cable glands. [b] Only permitted for Gc installations				

To meet the ingress protection requirement it may also be necessary to seal between cable glands, adapters and blanking elements and the enclosure (for example by means of a sealing washer or thread sealant).

NOTE 2 In order to meet the minimum requirement of IP54, threaded cable entry devices into threaded cable entry plates or enclosures of 6 mm or greater thickness need no additional sealing between the cable entry device and the entry plate or enclosure provided the axis of the cable entry device is perpendicular to the external surface of the cable entry plate or enclosure.

Where mineral-insulated metal sheathed cables are used, the requirement to achieve creepage distances shall be maintained by using a certified mineral insulated cable sealing device.

10.3 Connections of cables to equipment

Cable glands shall be installed in a manner that after installation they are only capable of being released or dismantled by means of a tool.

If additional clamping is required to prevent pulling and twisting of the cable transmitting the forces to the conductor terminations inside the enclosure, a clamp shall be provided, as close as practicable to the gland along the cable.

NOTE 1 Cable clamps within 300 mm of the end of the cable gland are preferred.

Cables shall be routed straight from the cable gland to avoid lateral tension that may compromise the seal around the cable.

Where cable glands, blanking elements and adapters with tapered threads are used in enclosures having gland plates with unthreaded entries care shall be taken to use appropriate fittings to maintain the enclosure integrity.

NOTE 2 Tapered threads include NPT threads.

When braided or armoured cables have been terminated within the cable gland, the body components that are intended to retain and secure the cable braid or armour should not be able to be released manually or opened by hand without the use of a tool.

The connection of cables to the electrical equipment shall be effected by means of cable glands appropriate to the type of cable used and shall maintain the explosion protection integrity of the relevant type of protection.

Where the threaded entry or hole size is different to that of the cable gland, a threaded adapter complying with Table 10 shall be fitted.

10.4 Additional requirements for entries other than Ex “d”, Ex “t” or Ex “nR”

If additional cable entry holes for other than Ex “d”, Ex “t” or Ex “nR” are required they may be made under the following conditions:

- permitted by the manufacturer’s documentation with area, size of holes and quantity of holes;
- entry holes either plain or threaded shall meet the tolerances given by the manufacturer.

Threaded holes in plastic enclosures should be at right angles to the face of the enclosure (due to the possible moulding methods for plastic enclosures, the wall of the enclosure may have draw angles). Surfaces with angles do not allow the gland and associated fittings inserted in the hole to fit square to the face, resulting in ineffective sealing.

Taper threaded holes in plastic enclosures are not recommended because the high stresses created during sealing of these threads may fracture the enclosure wall.

10.5 Unused openings

With the exception of enclosures containing only one intrinsically safe circuit, unused entries in the enclosure shall be sealed by blanking elements in accordance with Table 10 and that maintain the degree of ingress protection IP 54 or that required by the location, whichever is the higher. Blanking elements shall be of a type that can only be removed with the use of a tool.

For flameproof enclosures adapters shall not be used together with blanking elements.

10.6 Additional requirements for type of protection “d” – Flameproof enclosures

10.6.1 General

Where cables enter into flameproof equipment via flameproof bushings through the wall of the enclosure which are part of the equipment (indirect entry), the parts of the bushings outside the flameproof enclosure shall be protected in accordance with one of the types of protection listed in IEC 60079-0. For example, the exposed parts of the bushings are within a terminal compartment which may either be another flameproof enclosure or will be protected by type of protection “e”.

If an Ex “d” gland clamping by the sealing ring (compression) is used with braided or armoured cable, it shall be of the type where the braid or armour is terminated in the gland and compression takes place on the inner cable sheath. For fine braided cable, where the braid is less than 0,15 mm diameter and has coverage of at least 70 % compression only on the outer sheath is accepted.

NOTE 1 Flame propagation of flame may occur through the interstices between the strands of standard stranded conductors, or between individual cores of a cable. Special cable construction can be employed as means of reducing and preventing flame propagation. Examples include compacted strands, sealing of the individual strands, and extruded bedding. Further information is given in Annex E.

Flameproof cable glands, adapters or blanking elements, having parallel threads may be fitted with a sealing washer between the entry device and the flameproof enclosure provided that, after the washer has been fitted, the applicable thread engagement is still achieved. Thread engagement shall be at least five full threads. Suitable grease may be used provided it is non-setting, non-metallic and non-combustible and any earthing between the two is maintained.

Where taper threads are used, the connection shall be made wrench tight.

The addition of holes or alteration to thread form is only permitted when in compliance with the certification documents and completed by the manufacturer or certified workshops. Where the threaded entry or hole size is different to that of the cable gland, a flameproof threaded adapter complying with IEC 60079-1 shall be fitted which complies with thread engagement requirements detailed above. Unused cable entries shall be sealed with a flameproof blanking element complying with IEC 60079-1, which shall be fitted directly to the hole (no threaded adapter shall be used), and shall comply with thread engagement requirements detailed above and shall be secured against loosening.

NOTE 2 Non-threaded cable glands can be used if certified with the complete equipment or if certified as equipment.

10.6.2 Selection of cable glands

The cable entry system shall comply with one of the following:

a) Cable glands sealed with setting compound (barrier cable glands) in compliance with IEC 60079-1 and certified as equipment;
b) Cables and glands meeting all of the following:
   – cable glands comply with IEC 60079-1 and are certified as equipment
   – cables used comply with 9.3.2(a)
   – the connected cable is at least 3 m in length;
c) indirect cable entry using combination of flameproof enclosure with a bushing and increased safety terminal box;
d) mineral-insulated metal-sheathed cable with or without plastic outer covering with appropriate flameproof cable gland complying with IEC 60079-1;
e) flameproof sealing device (for example a sealing chamber) specified in the equipment documentation or complying with IEC 60079-1 and employing a cable gland appropriate to the cables used. The sealing device shall incorporate compound or other appropriate seals which permit stopping around individual cores. The sealing device shall be fitted at the point of entry of cables to the equipment.

NOTE 1 The minimum length of cable is to minimize the potential for flame transmission through the cable (see also Annex E);

NOTE 2 If the cable gland and actual cable are certified as a part of the equipment (enclosures) then compliance to 10.6.2 is not necessary.

10.7 Additional requirements for type of protection “t” – Protection by enclosure

The IP protection shall be as given in Table 11.

Table 11 – Level of protection, equipment group and ingress protection relationship

Level of protection	Group IIIC	Group IIIB	Group IIIA
“ta”	IP6X	IP6X	IP6X
“tb”	IP6X	IP6X	IP5X
“tc”	IP6X	IP5X	IP5X

Ex “t” glands, adapters or blanking elements, having parallel threads may be fitted with a sealing washer between the entry device and the “t” enclosure. If no washer is used the thread engagement shall be at least five full threads. Tapered threaded joints without an additional seal or gasket shall engage no less than 3½ threads.

10.8 Additional requirements for type of protection “nR” – Restricted breathing enclosure

The sealing of restricted-breathing “nR” enclosures shall be such as to maintain the restricted-breathing properties of the enclosure.

Where the cable used is not part of the certificate and/or instruction manual and is not effectively filled, it may be necessary to use a cable gland or other method (e.g. epoxy joint, shrinking tube) which seals around the individual conductors of the cable to prevent leakage from the enclosure.

A suitable sealing washer shall be fitted between the cable gland and the enclosure. Conduit or tapered threads will require the use of a thread sealant (see Clause 9).

11 Rotating electrical machines

11.1 General

Rotating electrical machinery shall additionally be protected against overload unless it can withstand continuously the starting current at rated voltage and frequency or, in the case of generators, the short-circuit current, without inadmissible heating. The overload protective device shall be:

a) a current-dependent, time lag protective device monitoring all three phases, set at not more than the rated current of the machine, which will operate in 2 h or less at 1,20 times the set current and will not operate within 2 h at 1,05 times the set current, or
b) a device for direct temperature control by embedded temperature sensors, or
c) another equivalent device.

11.2 Motors with type of protection “d” – Flameproof enclosures

11.2.1 Motors with a converter supply

Motors supplied at varying frequency and voltage by a converter supply require that either:

a) the motor has been type-tested for this duty as a unit in association with the converter specified in the descriptive documents according to IEC 60079-0 and with the protective device provided, or
b) if the motor has not been type-tested for this duty as a unit in association with the converter, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided. The effectiveness of the temperature control shall take into account power, speed range, torque and

frequency for the duty required and shall be verified and documented. The action of the protective device shall be to cause the motor to be electrically disconnected.

NOTE 1 In some cases, the highest surface temperature occurs on the motor shaft.

NOTE 2 A current-dependent time lag protective device (in accordance with 11.1) is not regarded as an “other effective measure”.

For motors with type of protection “e” terminal boxes, when using converters with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.2.2 Reduced-voltage starting (soft starting)

Motors with a soft start supply require that either:

a) the motor has been type tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) if the motor has not been type tested as a unit in association with the soft start device, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature (in accordance with 11.1) of the motor housing shall be provided, or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE 1 It is considered that soft starting is used for a short time period.

For motors with type of protection “e” terminal boxes, when using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.3 Motors with type of protection “e” – Increased safety

11.3.1 Mains-operated

In order to meet the requirements of 11.1 inverse-time delay overload protective devices shall be such that not only is the motor current monitored, but the stalled motor will also be disconnected within the time t_E stated on the marking plate. The current-time characteristic curves giving the delay time of the overload relay or release as a function of the ratio of the starting current to the rated current shall be held by the user.

The curves will indicate the value of the delay time from the cold state related to an ambient temperature of 20 °C and for a range of starting current ratios (I_A/I_N) of at least 3 to 8. The tripping time of the protective devices shall be equal to these values of delay ±20 %.

The properties of delta wound motors in the case of the loss of one phase should be specifically addressed. Unlike star wound motors, the loss of one phase may not be detected, particularly if it occurs during operation. The effect will be current imbalance in the lines feeding the motor and increased heating of the motor. A delta wound motor with a low torque load during start-up might also be able to start under this winding failure condition and therefore the fault may exist undetected for long periods. Therefore, for delta wound motor, phase imbalance protection shall be provided which will detect motor imbalances before they can give rise to excessive heating effects.

In general, motors designed for continuous operation, involving easy and infrequent starts which do not produce appreciable additional heating, are acceptable with inverse-time delay overload protection. Motors designed for arduous starting conditions or which are to be started frequently are acceptable only when suitable protective devices ensure that the limiting temperature is not exceeded.

Arduous starting conditions are considered to exist if an inverse-time delay overload protective device, correctly selected as above, disconnects the motor before it reaches its rated speed. Generally, this will happen if the total starting time exceeds 1,7 t_E.

Operation: Where the duty of the motor is not S1 (continuous operation at constant load), the user should obtain the appropriate parameters for the determination of suitability given a definition of operation.

Starting: It is preferred that the direct on-line starting time for the motor is less than the t_E time so that the motor protection device does not trip the motor during start-up. Where the starting time exceeds 80 % of the t_E time, the limitations associated with starting whilst maintaining operation within the machine instruction manual should be ascertained from the motor manufacturer.

Automatic reclosing (automatic restarting) is not recommended due to the increased risk of rotor sparking or insulation system sparking during the reclosing. If a motor must be automatically restarted, additional protective measures such as a specifically timed reclosure to match phase, type of protection “p”, transient voltage limiting devices, etc. should be considered.

As the voltage dips during a direct on-line start, the starting current decreases and the run-up time increases. Although these effects may tend to cancel out for small voltage dips, for voltages less than 85 % of U_N during start-up, the motor manufacturer should declare the associated limitations on start-up.

Motors may be limited by the manufacturer to a fixed number of start attempts.

In addition to the requirements of 11.1, protection relays for machines in accordance with type of protection “e” should:

a) monitor the current in each phase, and,
b) provide close overload protection to the fully loaded condition of the motor.

Inverse-time delay overload protection relays may be acceptable for motors of duty type S1 which have easy and infrequent starts. Where the starting duty is arduous or starting is required frequently, the protection device should be selected so that it ensures limiting temperatures are not exceeded under the declared operational parameters of the motor. Where the starting time exceeds 1,7 t_E, an inverse-time relay would be expected to trip the motor during start-up.

NOTE Under some circumstances, e.g. for duty types other than S1, the motor may be certified with the temperature detection and protection. If this is the case, the t_E time may not be identified.

11.3.2 Winding temperature sensors

In order to meet the requirements of 11.1 winding temperature sensors associated with protective devices shall be adequate for the thermal protection of the motor even when the motor is stalled. The use of embedded temperature sensors to control the limiting temperature of the motor is only permitted if such use is specified in the motor documentation. The time t_A specifies the response time of the temperature sensors and has to be verified.

NOTE 1 The type of built-in temperature sensors and associated protective device will be identified on the motor.

NOTE 2 By testing the protection device, verification of the time t_A (see also Annex C and IEC 60079-17) will be done by the user.

11.3.3 Machines with rated voltage greater than 1 kV

Machines with a rated voltage exceeding 1 kV shall be selected taking into account the values in Table G.1 of Annex G. If the total sum of the risk factors is greater than 6, then anti-condensation space heaters shall be employed, and need of special measures shall be employed to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

NOTE 1 If the machine is intended to operate under “special measures”, the certificate will have the symbol “X” in accordance with IEC 60079-0.

NOTE 2 Special measures could include pre-start ventilation, the application of fixed gas detection inside the machine or other methods specified in the manufacturer’s instructions.

NOTE 3 For all Ex “e” motors above 1 kV, manufactured according to the latest IEC 60079-7 standards, the stators will have been type tested in a gas environment and fitted with anti-condensation heaters.

11.3.4 Motors with converter supply

Motors supplied at varying frequency and voltage by a converter shall have been type tested for this duty in association with the converter and the protective device. The motor should be used within its electrical rating and the converter configuration should be set to match the motor rating information with respect to frequency range and any other specified parameters such as minimum carrier frequency. The converter configuration shall enable to adjust the parameter.

NOTE Permanent magnet motors operate as a generator while coasting after power is removed. For motors of level of protection “eb”, where the voltage can be greater than the rated voltage, the motor-converter system will be suitable for the voltages that will result.

11.3.5 Reduced-voltage starting (soft starting)

Motors with a soft start supply require either:

a) the motor has been type tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) if the motor has not been type tested as a unit in association with the soft start device, then, means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the temperature of the motor shall be provided or the speed control device ensures that the motor run up is such that the temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE It is considered that soft starting is used for a short time period.

When using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.4 Motors with type of protection “p” and “pD” – Pressurized enclosures

11.4.1 Motors with a converter supply

Motors supplied at varying frequency and voltage by a converter supply require that either:

a) the motor has been type tested for this duty as a unit in association with the converter specified in the descriptive documents according to IEC 60079-0 and with the protective device provided, or
b) if the motor has not been type tested for this duty as a unit in association with the converter, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided. The effectiveness

of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE 1 In some cases, the highest surface temperature occurs on the motor shaft.

NOTE 2 A current-dependent time lag protective device (in accordance with 11.1) is not regarded as an “other effective measure”.

For motors with type of protection “e” or “n” terminal boxes, when using convertors with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.4.2 Reduced-voltage starting (soft starting)

Motors with a soft start supply require that either:

a) the motor has been type tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) if the motor has not been type tested as a unit in association with the soft start device, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided, or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE It is considered that soft starting is used for a short time period.

When using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.5 Motors with type of protection “t” – Protection by enclosures supplied at varying frequency and voltage

11.5.1 Motors with a converter supply

Motors supplied at varying frequency and voltage by a converter supply require that either:

a) the motor has been type tested for this duty as a unit in association with the converter specified in the descriptive documents according to IEC 60079-0 and with the protective device provided, or
b) if the motor has not been type tested for this duty as a unit in association with the converter, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided. The effectiveness of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE 1 In some cases, the highest surface temperature occurs on the motor shaft.

NOTE 2 A current-dependent time lag protective device (in accordance with 11.1) is not regarded as an “other effective measure”.

Care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.5.2 Reduced-voltage starting (soft starting)

Motors with a soft start supply require that either:

a) the motor has been type tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) if the motor has not been type tested as a unit in association with the soft start device, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor housing shall be provided, or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE 1 It is considered that soft starting is used for a short time period.

When using a soft start device with high-frequency pulses in the output, care should be taken to ensure that any overvoltage spikes and higher temperatures which may be produced in the terminal box are taken into consideration.

11.6 Motors with type of protection “nA” – Non-sparking

11.6.1 Motors with converter supply

Motors supplied at varying frequency and voltage by a converter require that either:

a) the motor has been type tested, in accordance with IEC 60079-15, with the specific converter or with a comparable converter in reference to the output voltage and current specifications, or
b) if the motor has not been type tested for this duty as a unit in association with the converter, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the temperature of the motor shall be provided. The effectiveness of the temperature control taking into account power, speed range, torque and frequency for the duty required shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected. Alternatively the motor shall have its temperature class determined by calculation in accordance with IEC 60079-15.

11.6.2 Reduced-voltage starting (soft starting)

Motors with a soft start supply require either:

a) the motor has been type tested as a unit in association with the soft start device specified in the descriptive documents and with the protective device provided, or
b) if the motor has not been type tested as a unit in association with the soft start device, then means (or equipment) for direct temperature control by embedded temperature sensors specified in the motor documentation or other effective measures for limiting the surface temperature of the motor shall be provided, or the speed control device ensures that the motor run up is such that the surface temperature is not exceeded. The effectiveness of the temperature control or proper run up shall be verified and documented. The action of the protective device shall be to cause the motor to be disconnected.

NOTE It is considered that soft starting is used for a short time period.

11.6.3 Machines with rated voltage greater than 1 kV

Machines with a rated voltage exceeding 1 kV shall be selected taking into account the values in Table G.1 of Annex G). If the total sum of the risk factors is greater than 6, then anti-condensation space heaters shall be employed, or special measures shall be applied to ensure that the enclosure does not contain an explosive gas atmosphere at the time of starting.

NOTE 1 If the machine is intended to operate under “special measures”, the certificate will have the symbol “X” in accordance with IEC 60079-0.

NOTE 2 Special measures could include pre-start ventilation, the application of fixed gas detection inside the machine or other methods specified in manufacturer’s instructions.

12 Luminaires

Luminaires with fluorescent lamps and electronic ballasts in type of protection “e” or “nA” shall not be used where temperature class T5 or T6 is required or where the ambient temperature exceeds 60 °C.

NOTE 1 This restriction minimizes the risk of end of life (EOL) effects of the lamp.

For lamps with pins, the pins shall be made of brass.

Lamps (e.g. bi-pins, screw connections on tungsten lamps) using non-conductive materials with a conductive coating shall not be used unless tested with the equipment.

NOTE 2 This restriction is intended to apply to lamps where the pins or end caps could be plastic or ceramic with a conductive film coating.

13 Electric heating systems

13.1 General

Electric heating system components having only a component certificate, i.e. marked with a “U”, may only be used in an assembly of components (now being referred to as an equipment), when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Heaters shall have the following protection in addition to overcurrent protection unless it is installed as part of another certified assembly e.g. electric motor anti-condensation heater:

a) in addition to the protection required by Clause 7, in order to limit the heating effect due to earth-fault and earth-leakage currents, the following additional protection shall be installed in a TT or TN type system: a residual current device (RCD) with a rated residual operating current not exceeding 100 mA shall be used.

   Preference should be given to RCDs with a rated residual operating current of 30 mA.

   NOTE Additional information on RCDs is given in IEC 61008-1.

b) in an IT system, an insulation monitoring device shall be used to disconnect the supply whenever the insulation resistance is not greater than 50 ohms per volt of rated voltage.

   For short-circuit calculations, the load current of the complete trace heating circuit should be taken into consideration.

13.2 Temperature monitoring

Any temperature protective device, if required, shall be independent from any operating temperature control device and de-energize the electric heating system either directly or indirectly. Protective devices shall be manually reset only.

Requirements for the temperature monitoring systems are given in Table 12.

Table 12 – Requirements for the temperature monitoring systems

Electromechanical high temperature switch	Processor-controlled high temperature switch
Resetting only with tool	Resetting only possible with user code
Manual resetting	Resetting only by authorized personnel in control cabinet
Resetting only under normal operating conditions	Resetting only under normal operating conditions
Secured setting	Setting of temperature class only possible with hard-wired jumper and manufacturer's code
Independent of the controller	Independent of the controller
Sensor fail-safe function (e.g. if capillary tube fractures)	100 % sensor monitoring

13.3 Limiting temperature

The resistance heating device or unit shall be prevented from exceeding the limiting temperature when energized.

This shall be ensured by one of the following means:

a) a stabilized design using the temperature self-limiting characteristic of the resistance heating device;

b) a stabilized design of a heating system (under specified conditions of use).

NOTE 1 Astabilized design for EPL "Gb" or "Gc", does not normally need additional protection against excessive temperatures;.

c) a safety device according to 13.4.

The necessary data regarding relationships that influence the temperature of the resistance heating device shall be provided by the manufacturer in the documentation prepared in accordance with IEC 60079-0.

NOTE 2 For b) and c), the temperature of a resistance heating device is dependent on the relationships between various parameters which can include, but are not limited to:

– ambient temperature range;
– inlet and outlet temperature of the medium or temperature of the work piece;
– medium to be heated, with its physical properties (thermal conductivity, specific heat capacity, kinematic viscosity, Prandtl number, relative density);
– temperature class;
– heat output;
– heat flux, dependent on the physical properties of the medium, its flow velocity, the supply voltage and the permissible surface temperature;
– geometry of the heating unit (arrangement of the individual heating elements, angle of incidence, heat transfer).

13.4 Safety device

The protection offered by a safety device shall be achieved by sensing based on:

a) the temperature of the resistance heating device or, if appropriate, of its immediate surroundings, or

b) the temperature of the resistance heating device or the surrounding temperature and one or more other parameters.

NOTE Examples of other parameters for (b) include:

– in the case of liquids, a covering of the heating device of at least 50 mm can be ensured by means of a level monitor (dry run protection); or

– in the case of flowing media such as gas and air, the minimum throughput can be ensured by means of a flow monitor; or
– for the heating of work pieces, the heat transfer can be ensured by the fixing of the heating device or with auxiliary agents (heat-conducting cement).

For locations where EPL “Gb” or “Db” are required, the safety device shall

– de-energize the resistance heating device or unit either directly or indirectly.

For locations where EPL “Gc” or “Dc” are required, the safety device shall

– de-energize the resistance heating device or unit either directly or indirectly, or
– provide an output for an alarm intended to be located in a constantly attended location

Reset shall only be manual with the aid of a tool and only after the previously defined process conditions have returned, except when the information from the safety device is continuously monitored. In the event of failure of the sensor, the heating device shall be de-energized before the limiting temperature is reached.

The adjustment of the safety devices shall be locked and sealed and shall not be capable of being subsequently altered when in service.

Thermal fuses should be replaced only by parts specified by the manufacturer.

The safety device shall operate under the abnormal conditions and shall be additional to and functionally independent of any regulating device which may be necessary for operational reasons under the normal conditions.

13.5 Electrical trace heating systems

The outer metallic covering, metallic braid, or other equivalent electrically conductive material of the trace heater shall be bonded to the earthing system to provide an effective earthing path.

In applications where the primary earthing path is dependent on the metallic covering, metallic braid, or other equivalent electrically conductive material, the chemical resistance of the material shall be taken into account if exposure to corrosive vapours or liquids might occur.

Stainless steel type braids and sheaths typically have high resistance and may not provide effective earthing paths. Consideration should be given to alternative earthing means or supplemental earthing protection.

Additional requirements for electrical trace heating systems are provided in Annex F.

14 Additional requirements for type of protection “d” – Flameproof enclosures

14.1 General

Only Ex “d” equipment having a complete certificate shall be installed.

Ex “d” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless as part of an assembly of components (now being referred to as equipment), when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Additional holes or modification to entries shall only be made into an Ex “d” enclosure by the manufacturer or an appropriately qualified certified service facility.

Alteration of the internal components of the equipment is not permitted without re-evaluation of the equipment because conditions may be created inadvertently which lead to pressure-piling, change in temperature class, or other such issues that may invalidate the certificate.

Equipment marked for a specific gas, or marked for an equipment group plus a specific gas, and used in that specific gas atmosphere shall be installed in accordance with the requirements for the equipment group to which the specific gas belongs. For example, equipment marked "IIB + H_2" and used in a hydrogen atmosphere shall be installed as IIC equipment.

Aluminium conductors in Ex "d" flameproof enclosures should be avoided in those cases where a fault leading to potentially severe arcing involving the conductors may occur in the vicinity of a plain flanged joint. Adequate protection may be afforded by conductor and terminal insulation that prevents the occurrence of faults or by using enclosures with spigot or threaded joints.

14.2 Solid obstacles

When installing equipment, care shall be exercised to prevent the flameproof flange joint approaching nearer than the distance specified in Table 13 to any solid obstacle which is not part of the equipment, such as steelwork, walls, weather guards, mounting brackets, pipes or other electrical equipment, unless the equipment has been tested at a smaller distance of separation and has been documented.

Table 13 – Minimum distance of obstruction from the flameproof flange joints related to the gas group of the hazardous area

Gas group	Minimum distance mm
IIA	10
IIB	30
IIC	40

14.3 Protection of flameproof joints

Protection against corrosion of flameproof joints shall be maintained in accordance with the manufacturer's documentation. The use of gaskets is only permissible when specified in the manufacturer's documentation.

Flameproof joints shall not be painted.

Painting (by the user) of the enclosure after complete assembly is permitted, ensuring the electrostatic charging is avoided in accordance with 6.5.2. The application of grease to the flameproof joint faces will reduce, but not eliminate, the quantity of paint penetrating the gap.

The effect of the paint on the temperature rating of the enclosure should be taken into account. It should also be ensured that all markings remain readable.

Where the manufacturer's documentation does not address joint protection including use of grease then only corrosion inhibiting grease, such as petroleum jelly or soap-thickened mineral oils, may be applied to joint surfaces before assembly. The grease, if applied, shall be of a type that does not harden because of ageing, does not contain an evaporating solvent, and does not cause corrosion of the joint surfaces. Care in the selection and application of greases should be taken to ensure the retention of the non-setting characteristics and to allow subsequent separation of the joint surfaces.

NOTE 1 It is the user's responsibility to confirm the grease is suitable.

NOTE 2 If silicone based greases are used these can affect some types of gas detectors (see IEC 60079-29).

Where the enclosure is used in conjunction with gases allocated to Group IIC, tape shall not be applied.

Non-hardening grease-bearing textile tape may be employed outside of a straight flanged joint with the following conditions:

– where the enclosure is used in conjunction with gases allocated to Group IIA, the tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap. New tape should be applied whenever existing tape is disturbed;
– where the enclosure is used in conjunction with gases allocated to Group IIB, the gap between the joint surfaces should not exceed 0,1 mm, irrespective of the flange width. The tape should be restricted to one layer surrounding all parts of the flange joint with a short overlap. New tape should be applied whenever existing tape is disturbed.

14.4 Conduit systems

Flameproof sealing devices for conduit shall be:

a) provided with the equipment and detailed in the equipment documentation; or
b) as specified in the equipment documentation; or
c) compliant with IEC 60079-1.

Conduit sealing devices shall be provided, either as part of the flameproof enclosure or immediately or as close as practical to the entry to the flameproof enclosure using a minimum number of fittings.

NOTE 1 The above includes a requirement to provide a seal between close coupled enclosures unless these are supplied as a certified assembly by the manufacturer.

Conduit sealing devices, having parallel threads may be fitted with a sealing washer between the device and the flameproof enclosure provided that after the washer has been fitted, the applicable thread engagement is still achieved. Thread engagement shall be at least five full threads. Suitable grease may be used provided it is non-setting and any earthing between the two is maintained.

A conduit sealing device is considered as fitted immediately at the entry of the flameproof enclosure when the device is fixed to the enclosure either directly or through an accessory necessary for coupling according to the manufacturer’s instructions. The distance from the face of the seal closest to the enclosure (or intended end-use enclosure), and the outside wall of the enclosure (or intended end-use enclosure) should be as small as practical, but in no case more than the size of the conduit or 50 mm, whichever is the lesser.

NOTE 2 Gas or vapour leakage and propagation of flames may occur through the interstices between the strands of standard stranded conductors, or between individual cores of a cable. Special constructions can be employed as means of reducing leakage and preventing the propagation of flames. Examples include compacted strands, sealing of the individual strands, and extruded bedding. See also 9.3.2.

15 Additional requirements for type of protection “e” – Increased safety

15.1 General

Only Ex “e” equipment having a complete certificate shall be installed.

Ex “e” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

15.2 Maximum dissipated power of terminal box enclosures

Care shall be taken to ensure that the heat dissipated by the power loss within the enclosure does not result in temperatures in excess of the required equipment temperature class. This can be achieved by:

a) following the guidance given by the manufacturer relating to the permissible number of terminals, the conductor size and the maximum current, or

b) checking that the calculated dissipated power, using parameters specified by the manufacturer, is less than the rated maximum dissipated power.

The length of conductors should be kept as short as practicable as the basis of the calculations and type tests is that the conductor length is half the enclosure diagonal. Keeping the conductors short will ensure that on average the length does not exceed the basis of the type tests. Additional length of conductors inside the enclosure running at maximum permitted current may give rise to increased internal temperature that may exceed the temperature class.

Bunching of more than 6 conductors may also give rise to high temperatures that may exceed T6 and/or damage to the insulation and should be avoided.

The manufacturer's documentation shall comprise for each terminal size, the permissible number of terminals, the conductor size and the maximum current (see the example in Table 14).

Unless otherwise specified in the certificate:

– only Ex "e" terminals shall be included in the terminal box enclosure;

– no other components are allowed;

– only one conductor per one connecting point is allowed.

15.3 Conductor terminations

Some terminals, e.g. slot types, may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped.

Unless permitted by the manufacturer's documentation, two conductors of different cross-sections shall not be connected into one terminal unless they are first secured with a single compression type ferrule or other method specified by the manufacturer.

To avoid the risk of short-circuits between adjacent conductors in terminal blocks, the insulation of each conductor shall be maintained up to the metal of the terminal.

Where single screw saddle clamps are used with a single conductor, the latter should be shaped around the screw in the form of a "U" unless clamping of single conductors without "U" is permitted in the documentation supplied with the equipment.

15.4 Maximum number of conductors in relation to the cross-section and the permissible continuous current

If more than one combination of values is possible, then the information may be given by the manufacturer in the form of a table. If combinations of different current values and or cross-sections are used, then a calculation should be made by the installer using the table. An example of a calculation is shown in Table 14. If not all terminals are loaded at the same time then a load factor may also be used for the calculation.

Table 14 – Example of defined terminal/conductor arrangement – Maximum number of wires in relation to the cross-section and the permissible continuous current

Current A	**Conductors based on cross-section** in mm^2				
	1,5	2,5	4	6	
3					
6			a		
10	40				
16	13	26			
20	5	15	30		
25		7	17	33	
35			3	12	
50		b			
63					
Maximum number of terminals	20	13	15	16	

NOTE All incoming conductors and internal links count as conductors, earth connections do not count.

When using this table, the diversity factor or the rated load factor in accordance with IEC 61439 may be taken into consideration. Mixed sizes of conductors with circuits of different cross-sections and currents are possible when the table values are used in the respective proportions.

[a] Any number additionally.

[b] To be engineered by the manufacturer (with heat rise calculation).

Cross-section mm^2	**Current** A	**Quantity**	**=**	**Utilization**
1,5	10	20 (of 40)	=	50 %
2,5	20	5 (of 15)	=	33,3 %
4	25	2 (of 17)	=	11,7 %
		Total < 100 %	=	95,0 %

16 Additional requirements for types of protection “i” – Intrinsic safety

16.1 General

A fundamentally different type of protection philosophy has to be recognized in the installation of intrinsically safe circuits. The integrity of an intrinsically safe circuit has to be protected from the intrusion of energy from other electrical sources so that the safe energy limitation in the circuit is not exceeded, even when breaking, shorting or earthing of the circuit occurs. The principles apply equally to Group II and Group III intrinsically safe circuit of intrinsically safe apparatus and associated apparatus unless otherwise stated.

Associated apparatus should preferably be located outside the hazardous area or, if installed inside a hazardous area, shall be provided with another appropriate type of protection in accordance with Clause 5.

Where the properties of intrinsic safety can be impaired by ingress of moisture or dust or by access to conducting parts and in order to protect against unauthorized interference and damage, the components and internal wiring of intrinsically safe apparatus and associated apparatus (e.g. barriers) shall be mounted in a suitable enclosure. Alternative methods of mounting may be used if they offer similar integrity against interference and damage.

As a consequence of this principle, the aim of the installation rules for intrinsically safe circuits is to maintain separation from other circuits. Unless otherwise stated, requirements for intrinsically safe circuits shall apply to all levels of protection (“ia”, “ib” and “ic”).

The installation of energy-limited circuits “nL” shall comply with all the requirements for intrinsically safe circuits “ic”.

16.2 Installations to meet the requirements of EPL “Gb” or “Gc” and “Db” or “Dc”

16.2.1 Equipment

In installations to meet the requirements of EPL “Gb”, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IEC 60079-11, at least to level of protection “ib”.

In installations to meet the requirements of EPL “Gc”, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IEC 60079-11, at least to level of protection “ic”.

In installations to meet the requirements of EPL “Db”, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IEC 60079-11, for Group III at least to level of protection “ib”.

In installations to meet the requirements of EPL “Dc”, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IEC 60079-11, for Group III at least to level of protection “ic”.

Electrical equipment connected to the non-intrinsically safe terminals of an associated apparatus shall not be fed with a voltage supply greater than U_m shown on the label of the associated apparatus. The prospective short-circuit current of the supply shall not be greater than 1 500 A.

Limitation of the prospective short-circuit current, where higher fault levels exist, may be achieved by appropriate upstream fusing or protection.

Where U_m marked on the associated apparatus is less than 250 V it shall be installed in accordance with one of the following:

a) where U_m does not exceed 50 V a.c. or 120 V d.c., in a SELV or PELV system, or
b) via a safety isolating transformer complying with the requirements of IEC 61558-2-6, or technically equivalent standard, or
c) directly connected to apparatus complying with the IEC 60950 series, IEC 61010-1, or a technically equivalent standard, or
d) fed directly from cells or batteries.

All apparatus forming part of an intrinsically safe system should, where reasonably practicable, be identifiable as being part of an intrinsically safe system. See also 16.2.2.6 for marking of cables.

16.2.2 Cables

16.2.2.1 General

Only cables with rated insulation between the conductor to earth, conductor to screen and screen to earth of at least 500 V a.c. or 700 V d.c. shall be used in intrinsically safe circuits.

The diameter of individual conductors or strands of multi-stranded conductors within the hazardous area shall be not less than 0,1 mm.

16.2.2.2 Electrical parameters of cables

The electrical parameters (C_c and L_c) or (C_c and L_c/R_c) for all cables used shall be determined according to a), b) or c):

a) the most onerous electrical parameters provided by the cable manufacturer;
b) electrical parameters determined by measurement of a sample;

NOTE Annex H details a satisfactory method of determining the relevant parameters.

c) 200 pF/m and either 1 μH/m or 30 μH/Ω where the interconnection comprises two or three cores of a conventionally constructed cable (with or without screen).

Where a FISCO or FNICO system is used, the requirements for cable parameters shall comply with IEC 60079-25.

16.2.2.3 Earthing of conducting screens

Where a screen is required, except as in a) through c) below, the screen shall be electrically connected to earth at one point only, normally at the non-hazardous area end of the circuit loop. This requirement is to avoid the possibility of the screen carrying a possibly incendive level of circulating current in the event that there are local differences in earth potential between points that may be available for connection to earth.

If an earthed intrinsically safe circuit is run in a screened cable, the screen for that circuit shall be earthed at the same point as the intrinsically safe circuit which it is screening.

If an intrinsically safe circuit or sub-circuit which is isolated from earth is run in a screened cable, the screen shall be connected to the equipotential bonding system at one point.

Special cases:

a) If there are special reasons (for example when the screen has high resistance, or where screening against inductive interference is additionally required) for the screen to have multiple electrical connections throughout its length, the arrangement of Figure 2 may be used, provided that
   – the insulated earth conductor is of robust construction (normally at least 4 mm^2 but 16 mm^2 may be more appropriate for clamp type connections);
   – the arrangement of the insulated earth conductor plus the screen are insulated to withstand a 500 V a.c. rms or 700 V d.c. as applicable insulation test from all other conductors in the cable and any cable armour;
   – the insulated earth conductor and the screen are only connected to earth at one point which shall be the same point for both the insulated earth conductor and the screen, and would normally be at the non-hazardous end of the cable;
   – the insulated earth conductor complies with 9.3.7;

– the inductance/resistance ratio (L/R) of the cable, installed together with the insulated earth conductor, shall be established and shown to conform to the requirements of 16.2.2.5.

b) If the installation is effected and maintained in such a manner that there is a high level of assurance that potential equalization exists between each end of the circuit (i.e. between the hazardous area and the non-hazardous area), then, if desired, cable screens may be connected to earth at both ends of the cable and, if required, at any interposing points.

c) Multiple earthing through small capacitors (for example 1 nF, 1 500 V ceramic) is acceptable provided that the total capacitance does not exceed 10 nF.

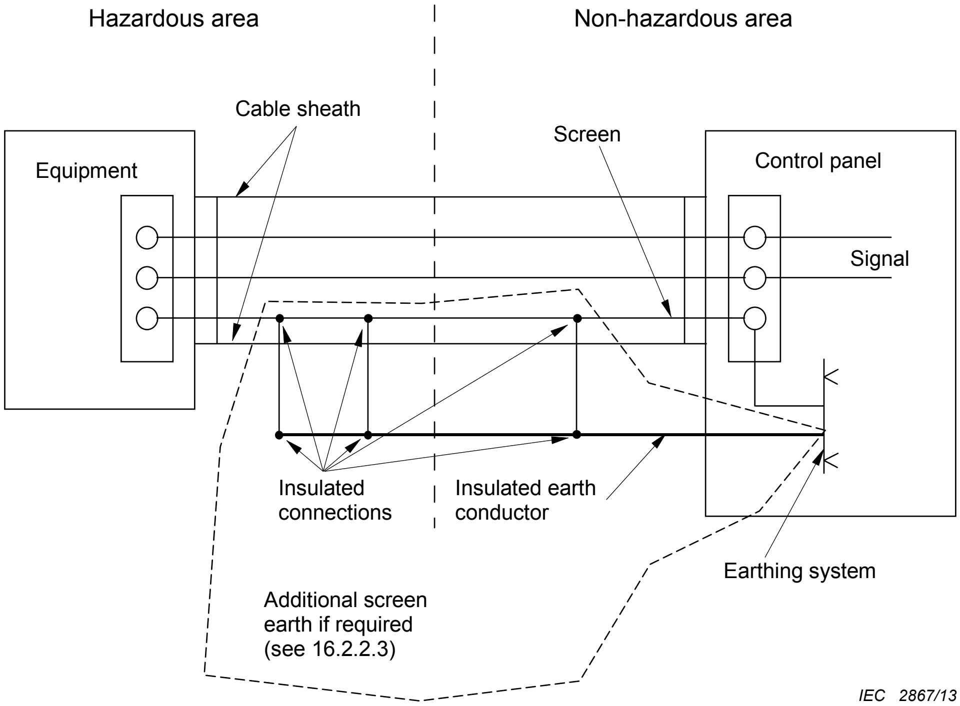

Figure 2 – Earthing of conducting screens

16.2.2.4 Cable armour bonding

The armour shall be bonded to the equipotential bonding system via the cable entry devices or equivalent, at each end of the cable run. Where there are interposing junction boxes or other equipment, the armour will normally be similarly bonded to the equipotential bonding system at these points. In the event that armour is required not to be bonded to the equipotential bonding system at any interposing point, care shall be taken to ensure that the electrical continuity of the armour from end to end of the complete cable run is maintained.

Where bonding of the armour at a cable entry point is not practical, or where design requirements make this not permissible, care shall be taken to avoid any potential difference which may arise between the armour and the equipotential bonding system giving rise to an incendive spark. In any event, there shall be at least one electrical bonding connection of the armour to the equipotential bonding system. The cable entry device for isolating the armour from earth shall be installed in the non-hazardous area or locations requiring EPL “Gc” or “Dc”.

16.2.2.5 Installation of cables and wiring

16.2.2.5.1 General

Installations with intrinsically safe circuits shall be erected in such a way that their intrinsic safety is not adversely affected by external electric or magnetic fields such as from nearby power lines or heavy current-carrying single core cables. This can be achieved, for example, by the use of screens and/or twisted cores or by maintaining an adequate distance from the source of the electric or magnetic field.

In addition to the cable requirements of 9.3.7, cables in both hazardous and non-hazardous areas shall be installed so as to ensure that intrinsically safe circuit cables cannot be inadvertently connected to circuit cables which are not intrinsically safe. This may be achieved by:

a) separating the different types of circuit cables, or
b) placing the cables so as to protect against the risk of mechanical damage (see also 9.3.7), or
c) using cables which are armoured, metal sheathed or screened for at least one type of circuit (e.g. all circuits which are not intrinsically safe are run in armoured cable or all intrinsically safe circuits are armoured).

16.2.2.5.2 Conductors

Conductors of intrinsically safe circuits shall not be carried in the same cable as conductors of circuits which are not intrinsically safe except as permitted by 16.6.

Conductors of intrinsically safe circuits, except as permitted by 16.2.2.7, shall not be in the same bundle or duct as conductors of circuits which are not intrinsically safe unless separated by an intermediate layer of insulating material or by an earthed metal partition. No separation is required if metal sheaths or screens are used for the intrinsically safe circuits or the circuits which are not intrinsically safe.

16.2.2.5.3 Unused cores in cables

Each unused core in a cable shall either

a) be adequately insulated from earth and from each other at both ends by the use of suitable terminations, or
b) if other circuits in the cable have an earth connection (e.g. via the associated apparatus), be connected to the earth point used to earth any intrinsically safe circuits in the same cable, but shall be adequately insulated from earth and from each other by the use of suitable terminations at the other end.

NOTE The use of heat-shrink tubing or terminating the unused core in suitable terminals would satisfy the requirements of 16.2.2.5.3.

16.2.2.6 Marking of cables

Cables containing intrinsically safe circuits shall be marked (except as below) to identify them as being a part of an intrinsically safe circuit. If sheaths or coverings are marked by a colour, the colour used for cables containing intrinsically safe circuits shall be light blue. Where intrinsically safe circuits have been identified by the use of light blue covered cable, then light blue covered cable shall not be used for other purposes in a manner or location which could lead to confusion or detract from the effectiveness of the identification of intrinsically safe circuits.

If all intrinsically safe circuit cables or all cables of circuits which are not intrinsically safe are armoured, metal sheathed or screened, then marking of intrinsically safe circuit cables is not required.

Alternative marking measures shall be taken inside measuring and control cabinets, switchgear, distribution equipment, etc. where there is a risk of confusion between cables of intrinsically safe and non-intrinsically safe circuits, in the presence of a blue neutral conductor. Such measures include:

- combining the cores in a common light blue harness;
- labelling;
- clear arrangement and spatial separation.

16.2.2.7 Cables carrying more than one intrinsically safe circuit

The requirements of 16.2.2.7 are in addition to those of 16.2.2.1 to 16.2.2.6.

Cables may contain more than one intrinsically safe circuit. Circuits which are not intrinsically safe shall not be carried in the same cables with intrinsically safe circuits except as noted in 16.6. Intrinsically safe "ic" circuits are permitted to be run together with intrinsically safe "ia" and "ib" circuits provided they are run in a cable of Type A or Type B as specified in 16.2.2.8.

The radial thickness of the conductor insulation shall be appropriate to the conductor diameter and the nature of the insulation. The minimum radial thickness shall be at least 0,2 mm.

Cables shall be of a type with the conductor insulation capable of withstanding a dielectric test of at least

- 500 V r.m.s. a.c. or 700 V d.c. applied between any armouring and/or screen(s) joined together and all the conductors joined together;
- 1 000 V r.m.s. a.c. or 1 400 V d.c. applied between a bundle comprising one half of the cable conductors joined together and a bundle comprising the other half of the conductors joined together. This test is not applicable to cables carrying more than one intrinsically safe circuit with conducting screens for individual circuits.

The dielectric strength tests shall be carried out by a method specified in an appropriate cable standard. Where no such method is available, the tests shall be carried out in accordance with the dielectric strength tests specified in IEC 60079-11.

NOTE The above requirement can be satisfied by providing evidence of testing from the cable supplier or manufacturer, or by the installer.

16.2.2.8 Types of cables carrying more than one intrinsically safe circuit and applicable fault considerations

The faults, if any, which shall be taken into consideration in cables carrying more than one intrinsically safe circuit used in intrinsically safe electrical systems depend upon the type of cable used.

- Type A

  For cables complying with the requirements of 16.2.2.7 and, in addition, with conducting screens providing individual protection for intrinsically safe circuits in order to prevent such circuits becoming connected to one another, coverage of such screens shall be at least 60 % of the surface area; no faults between circuits are taken into consideration.

- Type B

  Cable which is fixed, effectively protected against damage, complying with the requirements of 16.2.2.7 and, in addition, no circuit contained within the cable has a maximum voltage U_{O} exceeding 60 V; no faults between circuits are taken into consideration.

- Type C

  For cables complying with the requirements of 16.2.2.7 but not the additional requirements of Type A or Type B, it is necessary for "ia" or "ib" to take into consideration up to two short-circuits between conductors and, simultaneously, up to four open circuits of conductors. In the case of identical circuits, failures need not be taken into consideration provided that each circuit passing through the cable has a safety factor for spark ignition parameters of four times that required for level of protection "ia" or "ib".

16.2.3 Earthing of intrinsically safe circuits

Intrinsically safe circuits shall be either

a) isolated from earth, or

b) connected at one point to the equipotential bonding system if this exists over the whole area in which the intrinsically safe circuits are installed.

The installation method shall be chosen with regard to the functional requirements of the circuits and in accordance with the manufacturer's instructions.

More than one earth connection is permitted on a circuit, provided that the circuit is galvanically separated into sub-circuits, each of which has only one earth point.

In intrinsically safe circuits which are isolated from earth, attention shall be paid to the danger of electrostatic charging. A connection to earth across a resistance greater than 0,2 MΩ for example for the dissipation of electrostatic charges, is not deemed to be earthing.

Intrinsically safe circuits shall be earthed if this is necessary for safety reasons, for example in installations with safety barriers without galvanic isolation. They may be earthed if necessary for functional reasons, for example with welded thermocouples. If the intrinsically safe apparatus does not withstand the electrical strength test with at least 500 V a.c. r.m.s. to earth according to IEC 60079-11, a connection to earth for the equipment is to be assumed.

Where the equipment is earthed (e.g. by the method of mounting) and a bonding conductor is used between the equipment and the point of earth connection of the associated apparatus, conformity with a) or b) is not required. Such situations should receive careful consideration by a competent person so as to avoid danger from circulating fault currents. Particular care should be taken where the requirements of EPL “Ga” apparatus have to be met. If bonding conductors are employed, they should be adequate for the situation, have a copper cross-sectional area of no less than 4 mm^2, be permanently installed without the use of plugs and sockets, adequately mechanically protected, and have terminals which conform to the requirements of type of protection “e” with the exception of the IP rating.

In intrinsically safe circuits, the earthing terminals of safety barriers without galvanic isolation (for example Zener barriers) shall be:

1) connected to the equipotential bonding system by the shortest practicable route, or

2) for TN-S systems only, connected to a high-integrity earth point in such a way as to ensure that the impedance from the point of connection to the main power system earth point is less than 1 Ω. This may be achieved by connection to a switch-room earth bar or by the use of separate earth rods.

The conductor used shall be insulated to prevent invasion of the earth by fault currents which might flow in metallic parts with which the conductor could come into contact (for example control panel frames). Mechanical protection shall also be provided in places where the risk of damage is high.

The cross-section of the earth connection shall consist of

- at least two separate conductors each rated to carry the maximum possible current, which can continuously flow, each with a minimum of 1,5 mm^2 copper, or
- at least one conductor with a minimum of 4 mm^2 copper.

The provision of two earthing conductors should be considered to facilitate testing.

If the prospective short-circuit current of the supply system connected to the barrier input terminals is such that the earth connection is not capable of carrying such current, then the cross-sectional area shall be increased accordingly or additional conductors used.

If the earth connection is achieved via junction boxes, special care should be taken to ensure the continued integrity of the connection.

16.2.4 Verification of intrinsically safe circuits

16.2.4.1 General

Unless a certificate for the system is available defining the parameters for the complete intrinsically safe system, then the whole of 16.2.4 applies.

When installing intrinsically safe circuits, including cables, the maximum permissible capacitance and inductance, or L/R ratio and surface temperature shall not be exceeded. The permissible values shall be taken from the associated apparatus documentation or the marking plate.

The temperature classification of the equipment mounted in the hazardous area shall be determined from the label or documentation of that apparatus. The apparatus may have different classifications for different conditions of use (usually dependent on ambient temperature or input parameters U_i, I_i and P_i).

16.2.4.2 Descriptive system document

A descriptive system document shall be prepared by the system designer in which the items of electrical equipment and the electrical parameters of the system, including those of inter-connecting wiring, are specified.

The form in which information in the descriptive system document necessary to ensure safety should be kept is not stated precisely and may be covered by a number of sources such as drawings, schedules, maintenance manuals or similar documents. The documents should be prepared and maintained such that all the information relevant to a particular installation can be easily accessed.

NOTE A possible format for descriptive systems drawings and installation drawings can be found in IEC 60079-25.

16.2.4.3 Intrinsically safe circuits with only one source of power

The values of permissible input voltage U_i, input current I_i and input power P_i of each intrinsically safe apparatus shall be greater than or equal to the output voltage U_o, output current I_o and output power P_o of the source of power respectively.

The apparatus group of the intrinsically safe circuit is the same as the lowest gas grouping of any of the apparatus forming that circuit (for example a circuit with IIB and IIC apparatus will have a circuit grouping of IIB).

The level of protection of the intrinsically safe circuit is the lowest level of any of the apparatus forming that circuit (for example a circuit with “ib” and “ic” apparatus will have a level of protection “ic”).

The total inductance and capacitance of all the connected apparatus included in the system and any cable inductance and capacitance shall be less than or equal to L_o and C_o for the source of power.

Where both the total inductance and capacitance of all connected apparatus excluding the cable is greater than 1 % of L_o and C_o of the source of power respectively, then the acceptable values for L_o and C_o shall be halved and the allowable cable inductance and capacitance adjusted accordingly. Further information is provided in IEC 60079-25.

NOTE All connected apparatus includes any simple apparatus which may not have values for Li and Ci listed by the manufacturer. The source of power could be associated apparatus or other intrinsically safe apparatus.

As an alternative to assessment using the value of L_o the L_o/R_o ratio of the source of power may be used except where the total inductance of all connected apparatus is greater than 1 % of L_o. Where the total inductance of all connected apparatus is greater than 1 % of L_o the permitted L/R ratio of the cable must be recalculated in accordance with IEC 60079-25.

Once the limiting L/R ratio is established the L/R ratio of the cable shall be less than the limiting ratio and the value of C_o still applies to the connected apparatus and the cable.

Where the documentation of the source of power does not include a value for L_o/R_o, assessment of the cable for the L/R ratio cannot be used.

Guidance on the determination of cable parameters is given in 16.2.2.2.

16.2.4.4 Intrinsically safe circuits with more than one associated apparatus

If the intrinsically safe circuit contains more than one associated apparatus or if two or more intrinsically safe circuits are interconnected, the intrinsic safety of the whole system shall be checked by means of theoretical calculations or a spark ignition test in accordance with IEC 60079-11 and IEC 60079-25. The apparatus group, temperature class and the level of protection shall be determined.

Account shall be taken of the risk of feeding back voltages and currents into associated apparatus from the rest of the circuit. The rating of voltage and current-limiting elements within each associated apparatus shall not be exceeded by the appropriate combination of U_o and I_o of the other associated apparatus.

NOTE 1 For associated apparatus with linear current/voltage characteristics, the basis of calculation is given in Annex I. For associated apparatus with non-linear current/voltage characteristics, the guidance for interconnection of non-linear and linear intrinsically safe circuits in IEC 60079-25 can be used and/or expert advice sought.

NOTE 2 If the internal resistances $R_i = U_o/I_o$ of the associated apparatus are known for intrinsically safe circuits under consideration (linear characteristics according to IEC 60079-25), then the method given for the assessment of circuits with more than one source of power in IEC 60079-25 can be used as an alternative.

16.3 Installations to meet the requirements of EPL “Ga” or “Da”

Intrinsically safe circuits shall be installed in accordance with 16.2 except where modified by the following special requirements.

In installations with intrinsically safe circuits for locations requiring EPL “Ga”, the intrinsically safe apparatus and the associated apparatus shall comply with IEC 60079-11, level of protection “ia”. The circuit (including all simple apparatus, intrinsically safe apparatus, associated apparatus and the maximum allowable electrical parameters of inter-connecting cables) shall be of level of protection “ia”.

In installations to meet the requirements of EPL “Da”, the intrinsically safe apparatus and the intrinsically safe parts of associated apparatus shall comply with IEC 60079-11, for Group III at least to level of protection “ia”.

Associated apparatus with galvanic isolation between the intrinsically safe and non-intrinsically safe circuits is preferred.

Since only one fault in the equipotential bonding system, in some cases, could cause an ignition hazard, associated apparatus without galvanic isolation shall be used only if the earthing arrangements are in accordance with item 2) of 16.2.3 and any mains-powered equipment connected to the safe area terminals are isolated from the mains by a double wound transformer; the primary winding of the transformer shall be protected by an appropriately rated fuse of adequate breaking capacity.

If the intrinsically safe circuit is divided into sub-circuits, the locations requiring EPL “Ga” sub-circuit(s) including the galvanically isolating elements shall be level of protection “ia” but sub-circuits not in locations requiring EPL “Ga” need only be level of protection “ib” or “ic”.

NOTE 1 Galvanic isolation can be achieved via the associated apparatus or via galvanically isolating apparatus within an intrinsically safe circuit in EPL “Gb”, “Db”, “Gc”, “Dc” or non-hazardous locations.

If earthing of the circuit is required for functional reasons, the earth connection shall be made outside the locations requiring EPL “Ga” or “Da”, but as close as is reasonably practicable to the EPL “Ga” or “Da” equipment.

If earthing of the circuit is inherent in the circuit operation, as for example with a grounded tip thermocouple or a conductivity probe, this should be the only connection to earth, unless it can be demonstrated that no fault condition can arise as a result of the presence of more than one earth connection.

If part of an intrinsically safe circuit is installed in locations requiring EPL “Ga” or “Da” such that the apparatus and the associated apparatus are at risk of developing hazardous potential differences within the locations requiring EPL “Ga” or “Da”, e.g. through the presence of atmospheric electricity, a surge protection device shall be installed between each non-earth bonded core of the cable and the local structure as near as is reasonably practicable, preferably within 1 m, to the entrance to the locations requiring EPL “Ga” or “Da”. Examples of such locations are flammable liquid storage tanks, effluent treatment plants and distillation columns in petrochemical works. A high risk of potential difference is generally associated with a distributed plant and/or exposed equipment location, and the risk is not alleviated simply by using underground cables or tank installation.

The surge protection device shall be capable of diverting a minimum peak discharge current of 10 kA (8/20 μs impulse according to IEC 60060-1, ten operations). The connection between the protection device and the local structure shall have a minimum cross-sectional area equivalent to 4 mm^2 copper.

The spark-over voltage of the surge protection device shall be determined by the user and an expert for the specific installation.

The use of one or more low voltage surge protection devices in an intrinsically safe circuit modifies the way in which that circuit is considered to be earthed. This shall be taken into account in the design of the intrinsically safe system.

NOTE 2 Further guidance on the use of surge protection devices is given in IEC 60079-25.

The cable between the intrinsically safe apparatus in the locations requiring EPL “Ga” or EPL “Da” and the surge protection device shall be installed such that it is protected from lightning.

16.4 Simple apparatus

Simple apparatus is independent of the equipment protection level. Simple apparatus shall be clearly identifiable by durable labelling.

Labelling for simple apparatus may be by any party, including the manufacturer or installer, and may be by any designation marking or code preferred for the installation such that it is clearly identifiable as simple apparatus.

Additional information to assist in the identification of the simple apparatus such as a reference to the instrument loop number may also be marked.

Simple apparatus is defined in 3.5.5 and includes:

a) passive components, e.g. switches, junction boxes, resistors and simple semi-conductor devices;

b) sources of stored energy consisting of single components in simple circuits with well-defined parameters, e.g. capacitors or inductors, whose values are considered when determining the overall safety of the system;

c) sources of generated energy, e.g. thermocouples and photocells, which do not generate more than 1,5 V, 100 mA and 25 mW.

Simple apparatus shall also conform to the relevant requirements of IEC 60079-11.

NOTE 1 IEC 60079-11 excludes normal marking for explosion protected equipment in the case of simple apparatus.

For simple apparatus the maximum temperature can be determined from the values of P_o of the source of power to obtain the temperature class.

The maximum surface temperature shall be calculated in accordance with:

$$T = P_o R_{th} + T_{amb}$$

where

T is the surface temperature;

P_o is the power marked on the associated apparatus;

R_{th} is the surface temperature rise (K/W) (as specified by the component manufacturer for the applicable mounting conditions);

T_{amb} is the ambient temperature at the point of installation for the simple apparatus e.g. for a temperature sensor;

Simple apparatus with a total surface area above 20 mm^2 may be assigned a temperature class T4 if the maximum power supplied to it does not exceed the values given in Table 15 for the different ambient temperatures.

Table 15 – Variation in maximum power dissipation with ambient temperature for Equipment Group II

Maximum ambient temperature	°C	40	50	60	70	80
Maximum power dissipation	W	1,3	1,25	1,2	1,1	1,0

Small components may also be assigned a temperature class T4 or T5 according to the following limitations:

a) Components with a surface area smaller than 20 mm^2 (excluding lead wires) may be classified as T4 if their surface temperature does not exceed 275 °C.

b) Components with a surface area greater than 20 mm^2 but less than 1 000 mm^2 (excluding lead wires) may be classified as T4 if their surface temperature does not exceed 200 °C.

c) Components with a surface area smaller than 1 000 mm^2 (excluding lead wires) may be classified as T5 if their surface temperature does not exceed 150 °C.

NOTE 2 Adjustment of the maximum power limitations for simple apparatus cannot be applied for Group III.

Where it is necessary that the simple apparatus maintains the integrity of the isolation from earth of the intrinsically safe circuit, it shall be capable of withstanding a test voltage to earth of 500 V a.c. rms, or 700 V d.c., or twice the voltage of the intrinsically safe circuit whichever is greater.

Terminals shall be separated by a distance of at least 50 mm from non intrinsically safe terminals or connections or provided with other means of separation in accordance with IEC 60079-11.

Simple apparatus should not interconnect intrinsically safe circuits unless specifically permitted by the documentation.

NOTE 3 The requirements for isolation and separation of terminals are derived from IEC 60079-11.

Terminal boxes and switches in intrinsically safe circuits can be assumed to have a temperature rise of less than 40 K and can thus have a temperature classification of T6 at ambient temperature not exceeding 40 °C, T5 at an ambient temperature not exceeding 55 °C or T4 at an ambient temperature not exceeding 80 °C.

16.5 Terminal boxes

16.5.1 General

Where the ingress of moisture or dust or access to conducting parts can impair the properties of separate intrinsically safe circuits or lead to an un-assessed combination of intrinsically safe circuits, these circuits shall be installed such that this segregation is not impaired. Alternative methods of mounting may be used if they offer similar integrity against interference and damage.

The terminal box used shall be suitable for the environment in which it is installed e.g. usually an enclosure of at least IP54 is desirable. Cable entry devices shall maintain the degree of protection of the enclosure.

The segregation between the intrinsically safe wiring terminals shall be at least 3 mm from earthed parts.

The terminal boxes should be marked with “WARNING – Intrinsically safe circuits” or technically equivalent text.

NOTE The use of an increased safety enclosure with suitably rated increased safety terminals will satisfy the requirements of 16.5.2 and 16.5.3.

16.5.2 Terminal boxes with only one intrinsically safe circuit

There are no additional requirements for one intrinsically safe circuit.

16.5.3 Terminal boxes with more than one intrinsically safe circuit

Except where an assessment of the combination proves that the intrinsic safety of a combination of intrinsically safe circuits is not impaired, in order to maintain the requirements for intrinsic safety, terminal boxes shall comply with the following minimum requirements:

– In addition to the enclosure requirements of 16.5.1 the enclosure shall meet the requirements as given in IEC 60079-0 for non-metallic enclosures and non-metallic parts of enclosures, metallic enclosures and metallic parts of enclosures as appropriate.

  NOTE The requirements of IEC 60079-0 for non-metallic enclosures and non-metallic parts of enclosures include a consideration of, for example: impact resistance, resistance to light, and artificial ageing. The requirements of IEC 60079-0 for metallic enclosures and metallic parts of enclosures include a consideration of for example: impact resistance, and the amount of light metal used in alloys.

– The clearance distance between bare conducting parts of connection facilities shall be at least 6 mm between the separate intrinsically safe circuits.

16.5.4 Terminal boxes with non-intrinsically safe and intrinsically safe circuits

In addition to the requirements of 16.5.3 terminal boxes which contain both intrinsically and non-intrinsically safe circuits shall comply with the following minimum requirements:

a) Where the terminal box is located in a hazardous area, the enclosure and any non-intrinsically safe items shall fully comply with an appropriate explosion-protection technique
b) The clearance distance between bare conducting parts of intrinsically safe circuits and non-intrinsically safe circuits shall be at least 50 mm or as defined in IEC 60079-11.
c) The covers of the enclosure permitting access to energized non-intrinsically-safe circuits shall have a label per item “WARNING – DO NOT OPEN WHEN ENERGIZED”; or
d) All bare live parts not protected by the type of protection "i" shall have a separate internal cover providing at least the degree of protection IP30 when the enclosure of the apparatus is open. Additionally a label shall be provided on the internal cover stating “WARNING – NON-INTRINSICALLY SAFE CIRCUITS PROTECTED BY INTERNAL IP30 COVER”.

NOTE The purpose of the internal cover, when fitted, is to provide a minimum acceptable degree of protection against the access to energized non-intrinsically-safe circuits when the enclosure is opened for short periods to permit live maintenance of intrinsically-safe circuits. The cover is not intended to provide protection from electrical shock.

The terminals of the intrinsically safe circuits shall be marked for clear identification to differentiate them from the terminals of non-intrinsically safe circuits.

This marking may be by the use of colour, in which case it shall be light blue.

16.5.5 Plugs and sockets used for external connections

Plugs and sockets used for the connection of external intrinsically safe circuits shall be separate from, and non-interchangeable with, those of circuits which are not intrinsically safe. Where the equipment is fitted with more than one plug and socket for external connections and interchange could adversely affect the type of protection, such plugs and sockets shall either be arranged so that interchange is not possible, e.g. by keying, or mating plugs and sockets shall be identified, e.g. by marking or colour coding, to make interchange obvious.

Where a connector carries earthed circuits and the type of protection depends on the earth connection, then the connector should be constructed in accordance with the requirements given in IEC 60079-11 relating to earth conductors, connections and terminals.

16.6 Special applications

For some special applications, such as the monitoring of power cables, circuits using the principles of intrinsic safety are included in the same cable as power circuits. Such installations require a specific analysis of the risks involved.

For special applications, intrinsically safe circuits are permitted in the same plug and socket assembly as circuits which are not intrinsically safe, provided that it meets the requirements of IEC 60079-11 and the part of IEC 60079 appropriate to the type of protection used to protect the non-intrinsically safe circuits and that intrinsic safety is not required when the other circuits are energized.

17 Additional requirements for pressurized enclosures

17.1 General

Only Ex “p” equipment having a complete certificate shall be installed.

Ex “p” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area.

Furthermore, uncertified enclosures (industrial enclosures) used together with a certified control/purging device shall not be installed. It is always required that the complete unit and control/purging device and associated device are certified as a unit.

Pressurised enclosures and components having only a component certificate, i.e. marked with an “U”, shall not be installed in the hazardous area unless they are part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

17.2 Type of protection “p”

17.2.1 General

Unless it has been assessed as a whole, the complete installation shall be checked for compliance with the requirements of the documentation and this standard.

The required type of protection “pxb”, “pyb” or “pzc” is determined by the EPL requirements for the location and by whether the enclosure contains equipment not meeting “Gc” in accordance with Table 16.

Table 16 – Determination of type of protection (with no flammable release within the enclosure)

EPL	Enclosure contains equipment not meeting EPL “Gc” requirements	Enclosure contains equipment meeting EPL “Gc” requirements
“Gb”	Type “pxb”	Type “pyb”
“Gc”	Type “pxb” or “pzc”	No pressurization required
IEC 60079-2 requires that equipment of type of protection “py” will only contain equipment of type of protection “d”, “e”, “i”, “m”, “nA”, “nC”, “o” or “q”.		

17.2.2 Ducting

All ducts and their connecting parts shall be able to withstand a pressure equal to:

a) 1,5 times the maximum overpressure, specified by the manufacturer of the pressurized equipment, for normal operation, or

b) the maximum overpressure that the pressurizing source can achieve with all the outlets closed where the pressurizing source (for example a fan) is specified by the manufacturer of the pressurized equipment,

with a minimum of 200 Pa (2 mbar).

The materials used for the ducts and connecting parts shall not be adversely affected by the specified protective gas nor by the flammable gas or vapours in which they are to be used.

The points at which the protective gas enters the supply duct(s) shall be situated in a non-hazardous area, except for cylinder supplied protective gas.

Ducting should be located in a non-hazardous area as far as is reasonably practicable. If ducting passes through a hazardous area and the protective gas is at a pressure below atmospheric then the ducting shall be free from leaks.

Ducts for exhausting the protective gas should preferably have their outlets in a non-hazardous area. Consideration shall otherwise be given to the fitting of spark and particle barriers (i.e. devices to guard against the ejection of ignition-capable sparks or particles) as shown in Table 17.

NOTE During the purge period a small hazardous area could exist at the duct outlet.

Table 17 – Use of spark and particle barriers

EPL requirements for the location of exhaust duct outlet	**Equipment**	
	A	**B**
"Gb"	Required[a]	Required[a]
"Gc"	Required	Not required
A: Equipment which may produce ignition-capable sparks or particles in normal operation. B: Equipment which does not produce ignition-capable sparks or particles in normal operation.		
[a] If the temperature of the enclosed equipment constitutes a hazard upon failure of pressurization, a suitable device shall be fitted to prevent the rapid entry of the surrounding atmosphere into the pressurized enclosure.		

Pressurizing equipment, such as an inlet fan or compressor, which is used to supply protective gas should preferably be installed in a non-hazardous area. Where the drive motor and/or its control equipment are located within the supply ducting, or where the installation in a hazardous area cannot be avoided, the pressurizing equipment shall be suitably protected.

17.2.3 Action to be taken on failure of pressurization

17.2.3.1 General

Pressurization control systems are sometimes fitted with override devices or "maintenance switches" which are intended to allow the pressurized enclosure to remain energized in the absence of pressurization, e.g. when the enclosure door has been opened.

Such devices shall be used in a hazardous area only if the specific location has been assessed to ensure that potentially flammable gas or vapour is absent during the period of use ("gas-free" situation). The enclosure should be de-energized at once if flammable gases are detected while operating under these conditions and re-purged before it is put back into service.

It is only necessary to re-purge the enclosure after pressurization has been re-established if flammable gas was detected in the area while the manual override was in operation.

17.2.3.2 Equipment without an internal source of release

17.2.3.2.1 General

An installation comprising electrical equipment without an internal source of release shall comply with Table 18 when the pressurization with the protective gas fails.

Pressurized enclosures protected by static pressurization should be moved to a non-hazardous area for refilling if pressurization is lost.

If static pressurization is applied, the pressure monitoring devices shall lock out if pressure is lost and shall only be reset after pressure has been restored following refilling.

Table 18 – Summary of protection requirements for enclosures without an internal source of release

EPL requirement	Enclosure contains equipment not meeting EPL “Gc” requirements without pressurization	Enclosure contains equipment meeting EPL “Gc” requirements without pressurization
“Gb”	Alarm and switch-off [a] (Apply 17.2.3.2.2 and 17.2.3.2.3)	Alarm [b] (Apply 17.2.3.2.3)
“Gc”	Alarm [b] (Apply 17.2.3.2.3)	No pressurisation required
Restoration of pressurization should be completed as soon as possible, but in any case within 24 h. During the time that the pressurization is inoperative, action should be taken to avoid the entry of flammable material into the enclosure. Provided that pressurized equipment is switched off automatically upon pressurization failure, an additional alarm may not be necessary for safety, even in locations requiring EPL “Gb”. If power is not switched off automatically, e.g. in a locations requiring EPL “Gc”, an alarm is the minimum action that is recommended if combined with immediate action by the operator to restore the pressurization or switch off the equipment. Equipment within the pressurized enclosure suitable for the EPL requirements of the external location need not be switched off when pressure fails. However, care should be taken to ensure that there is no trapped flammable material inside the enclosed equipment which may leak out into the larger pressurized enclosure where work involving the creation of ignition capable sparks may occur.		
a If automatic switch-off would introduce a more dangerous condition, other precautionary measures should be taken, for example duplication of protective gas supply. b If the alarm operates, immediate action should be taken, for example to restore the integrity of the system.		

17.2.3.2.2 Automatic switch-off

An automatic device shall be provided to switch off the electrical supply to the equipment when the overpressure and/or protective gas flow falls below the minimum prescribed value.

In addition, an audible or visible alarm may be necessary. When such switching off might jeopardize the safety of the installation and safety is otherwise ensured, a continuous audible or visible alarm shall be provided until pressurization is restored or other appropriate measures are taken, including switching off with a known delay.

If automatic switch-off would introduce a more dangerous condition, other precautionary measures should be taken, for example duplication of protective gas supply.

Equipment within the pressurized enclosure suitable for the EPL requirements of the external location need not be switched off when pressure fails. However, care should be taken to ensure that there is no trapped flammable material inside the enclosed equipment, which may leak out into the larger pressurized enclosure where work involving the creation of ignition capable sparks may occur.

17.2.3.2.3 Alarm

If the internal pressure or flow of protective gas falls below the minimum prescribed value, a signal that is immediately apparent to the operator shall indicate the loss of pressure. The pressurization system shall be restored as soon as possible, or else the electrical supply shall be switched off manually.

17.2.3.3 Equipment with an internal source of release

Equipment with an internal source of release shall be installed in accordance with the manufacturer's instructions.

In particular, any containment system safety devices that are required for safety but which were not actually supplied with the equipment, e.g. sample flow limiters, pressure regulators or in-line flame arrestors, should be fitted by the user.

Where the pressurized enclosure has an internal containment system that allows process fluids or gases to be taken into the enclosure, the likelihood and effect of the pressurizing gas leaking into the process system should be considered. For example, if a low-pressure process gas in a containment system is at a lower pressure than the pressurizing air, any leakage path into the containment system will allow air into the process and produce a potentially adverse or dangerous effect on the process.

In the event of failure of the protective gas, an alarm shall be given and corrective action taken to maintain the safety of the system.

The action to be taken on pressure or flow failure should be decided by the user, taking into account at least the following considerations:

a) the manufacturer's recommendations;
b) the nature of the release from the containment system (e.g. "none", "limited" or "unlimited");
c) the constituents of the internal release, e.g. liquid or gas, and their flammability limits;
d) whether or not the flammable substance supply is automatically shut off upon pressure/flow failure;
e) the nature of the equipment inside the enclosure, e.g. incendive, suitable for locations requiring EPL "Gb" or "Gc", and its proximity to the source of release;
f) the external EPL requirements, e.g. "Gb" or "Gc";
g) the type of protective gas used, e.g. air or inert gas. In the latter case, the enclosure should always be re-purged after pressure has been lost to restore the high concentration of inert gas (and low concentration of oxygen) required to provide adequate protection;
h) the consequences of unannounced automatic shutdown of the equipment.

Where the sample gas has a high upper explosive limit (UEL) e.g. > 80 %, or where the gas is capable of reacting exothermically even in the absence of air, e.g. ethylene oxide, it is not possible to protect the enclosure with inert gas using "leakage compensation" techniques. The use of the "continuous flow" technique with air or inert gas is suitable if the flow rate is high enough to dilute the release to a concentration below 25 % of the lower explosive limit (LEL), or to a level below which decomposition cannot take place.

17.2.4 Multiple pressurized enclosures with a common safety device

When a source of protective gas is common to separate enclosures, the protective measures may be common to several, provided that the resulting protection takes account of the most unfavourable conditions in the whole assembly.

If the protective devices are common, the opening of a door or cover need not switch off the electrical supply to the whole assembly or initiate the alarm provided that

– the said opening is preceded by switching off the electrical supply to that particular equipment, except to such parts as are protected by a suitable type of protection,
– the common protective device continues to monitor the pressure in all the other enclosures of the group.

17.2.5 Purging

The minimum purge time, specified by the manufacturer, for the pressurized enclosure shall be increased by the minimum additional purging duration per unit volume of ducting, specified by the manufacturer, multiplied by the volume of the ducting.

If the concentration in the atmosphere within the enclosure and the associated ducting, for locations requiring EPL “Gc”, is well below the lower flammable limit (for example 25 % LEL) purging may be omitted. Additionally, gas detectors may be used to check whether the gas in the pressurized enclosure is flammable.

17.2.6 Protective gas

The protective gas used for purging, pressurization and continuous dilution shall be non-combustible and non-toxic. It shall also be substantially free from moisture, oil, dust, fibres, chemicals, combustibles and other contaminating material that may be dangerous or affect the satisfactory operation and integrity of the equipment. It will usually be air, although an inert gas may be used, particularly when there is an internal source of release of flammable material. The protective gas shall not contain more oxygen by volume than that normally present in air.

Where air is used as the protective gas, the source shall be located in a non-hazardous area and usually in such a position as to reduce the risk of contamination. Consideration shall be given to the effect of nearby structures on air movement and of changes in the prevailing wind direction and velocity.

Care should be taken to keep the temperature of the protective gas below 40 °C at the inlet of the enclosure. In special circumstances, a higher temperature may be permitted or a lower temperature may be required, in which case the temperature shall be marked on the pressurized enclosure.

Where inert gas is used, particularly in large enclosures, measures shall be taken to prevent the danger of suffocation. Pressurized enclosures using inert gas as the protective gas should be marked to indicate the hazards, for example:

“WARNING – THIS ENCLOSURE CONTAINS INERT GAS AND THERE MAY BE A DANGER OF SUFFOCATION. THIS ENCLOSURE ALSO CONTAINS A FLAMMABLE SUBSTANCE THAT MAY BE WITHIN THE FLAMMABLE LIMITS WHEN EXPOSED TO AIR”

17.3 Type of protection “pD”

17.3.1 Sources of protective gas

In certain circumstances, such as where it is necessary to maintain operation of equipment, it may be advisable to provide two sources of protective gas so that the alternative source may take over in the event of failure of the primary source. Each source shall be capable of maintaining, independently, the required level of pressure or rate of supply of protective gas.

If any of the equipment inside the enclosure is not suitable for a dust atmosphere, upon loss of pressure, the requirements of Table 19 shall be implemented.

Table 19 – Summary of protection requirements for enclosures

EPL	Type of equipment in the enclosure	
	Ignition capable equipment	Equipment with no sources of ignition in normal operation
Db	Automatic switch-off (Apply 17.3.2)	Alarm (Apply 17.3.3)
Dc	Alarm (Apply 17.3.3)	No pressurization required

17.3.2 Automatic switch-off

An automatic device shall be provided to switch off the electrical supply to the equipment and initiate an audible or visible alarm when the overpressure and/or protective gas flow falls below the minimum prescribed value. When such switching off might jeopardize the safety of the installation and safety is otherwise ensured, a continuous audible or visible alarm shall be provided until pressurization is restored or other appropriate measures are taken, including switching off with a known delay.

17.3.3 Alarm

If the internal pressure or flow of protective gas falls below the minimum prescribed value, a signal which is immediately apparent to the operator shall indicate the loss of pressure. The pressurization system shall be restored as soon as possible, or else the electrical supply shall be switched off manually.

17.3.4 Common source of protective gas

When a source of protective gas is common to separate enclosures, the protective measures may be common to several, provided that the resulting protection takes account of the most unfavourable conditions in the whole assembly.

If the protective devices are common, the opening of a door or cover need not switch off the electrical supply to the whole assembly or initiate the alarm provided that

– the said opening is preceded by switching off the electrical supply to that particular equipment, except to such parts as are protected by a suitable type of protection,
– the common protective device continues to monitor the pressure in all the other enclosures of the group, and
– the subsequent switching on of the electrical supply to that particular equipment is preceded by the applicable cleaning procedure.

17.3.5 Switching on electrical supply

The purging of pressurised enclosure for dust is not permitted. Before switching on the electrical supply to the equipment on start-up or after shutdown, it shall be verified that dust has not penetrated the enclosure or associated ducts in such a concentration that is likely to create a potential dust hazard. It shall be taken into account in making such an assessment:

1) the need for a substantial safety margin, and
2) the level of concentration in air of the applicable explosive dust required for a hazard to exist, and, if applicable,
3) the thickness of dust layers where there is a potential for combustion to occur due to heating.

Doors and covers which can be opened without the use of tools shall be interlocked so that automatically on opening the electrical supply is switched off from all parts not otherwise protected. The supply shall be prevented from being switched on again until the doors and covers have been re-closed.

17.4 Rooms for explosive gas atmosphere

17.4.1 Pressurized rooms

The term “room” applies equally to a single room, multiple rooms or to a building, which allows for full bodily personnel access. Types of protection “px”, “py”, “pz”, “pxb”, “pyb”, “pzc”, and “pv” are included (see also IEC 60079-13).

Types of protection “px” and “pxb” allow for “Gb” or “Db” equipment protection level (EPL) within the pressurized room to be reduced to permit the use of non-explosion protected equipment by maintaining an internal overpressure and diluting when there is an internal source of release. This permits unprotected equipment to be installed within the pressurized room except for pressurization defined safety devices.

NOTE Because types of protection "px" and "pxb" reduce the EPL to none (a non-defined EPL) there are more onerous requirements concerning its application with respect to interlocks, alarms, etc.

Types of protection "py" and "pyb" allow for "Gb" equipment protection level (EPL) within the pressurized room to be reduced to "Gc" by maintaining an internal overpressure and diluting when there is an internal source of release. This permits EPL "Gc" equipment to be installed within the pressurized room except for pressurization defined safety devices.

Types of protection "pz" and "pzc" allow for "Gc" or "Dc" equipment protection level (EPL) within the pressurized room to be reduced to permit the use of non-explosion protected equipment by maintaining an internal overpressure and diluting when there is an internal source of release. This permits unprotected equipment to be installed within the pressurized room except for pressurization defined safety devices.

Type of protection "pv" is in essence protection by dilution, and allows for the required "Gb" or Gc" equipment protection level (EPL) within the pressurized room to be reduced to permit the use of non-explosion protected equipment where there is only an internal source of release and the pressurized room is located in a non-hazardous area.

17.4.2 Analyser houses

Requirements for electrical installations in analyser houses are given in IEC/TR 60079-16 and IEC 61285.

18 Additional requirements for type of protection "n"

18.1 General

Only Ex "n" equipment having a complete certificate shall be installed.

Ex "n" enclosures and components having only a component certificate, i.e. marked with a "U", shall not be installed in the hazardous area unless they are part of an assembly of components (now being referred to as an equipment), when the components in the equipment are permitted by a full Ex certificate which may contain an "X" and the equipment label carries full Ex marking including temperature class.

Type of protection "n" is divided into 3 sub-types:

"nA" non-sparking equipment;

"nC" sparking equipment in which the contacts are suitably protected other than by a restricted-breathing enclosure or energy limitation;

"nR" restricted breathing enclosures.

NOTE For "nL" see Clause 16.

18.2 "nR" equipment

"nR" equipment shall be installed in a way that allows easy access to any test port.

Equipment should be provided with a test port to enable testing of restricted breathing properties to be carried out after installation and during maintenance. See also information given in IEC 60079-15.

NOTE Test port exemptions for some types of luminaires are given in IEC 60079-15.

The installation instructions provided with the equipment containing information on the selection of either cable glands and cables or conduit entry devices should be observed.

The effects of the sun's direct heating and other sources of heating or cooling on the enclosure should be taken into account.

The use of a restricted-breathing enclosure to protect against ignition from sparking contacts is not advisable where, because of high internal air temperatures, there is an increased risk of drawing the explosive atmosphere into the enclosure when the equipment is de-energized. Duty cycle of this type of equipment should also be considered because of the increased probability that the equipment might be de-energized when flammable gas or vapour surrounds the enclosure.

18.3 Combinations of terminals and conductors for general connection and junction boxes

Care shall be taken to ensure that the heat dissipated within the enclosure does not result in temperatures in excess of the required equipment temperature class. This can be achieved by:

a) following the guidance given by the manufacturer relating to the permissible number of terminals, the conductor size and the maximum current, or
b) checking that the calculated dissipated power, using parameters specified by the manufacturer, is less than the rated maximum dissipated power.

The length of the conductors inside the enclosure should not exceed the diagonal length of the enclosure as this is the basis of calculations and type tests. Additional lengths of the conductors inside the enclosure running at maximum permitted current may give rise to increased internal temperature that may exceed the temperature class.

Bunching of more than 6 conductors may also give rise to high temperatures that may exceed T6 and/or damage the conductor insulation and should be avoided.

18.4 Conductor terminations

Some terminals e.g. slot types, may permit the entry of more than one conductor. Where more than one conductor is connected to the same terminal, care shall be taken to ensure that each conductor is adequately clamped.

Unless permitted by the manufacturer’s documentation, two conductors of different cross-sections shall not be connected into one terminal unless they are first secured with a single compression type ferrule or other method specified by the manufacturer.

To avoid the risk of short-circuits between adjacent conductors in terminal blocks, the insulation of each conductor shall be maintained up to the metal of the terminal.

Where single screw saddle clamps are used with a single conductor, the latter should be shaped around the screw in the form of a “U” unless clamping of single conductors without “U” is permitted in the documentation supplied with the equipment.

19 Additional requirements for type of protection “o”– Oil immersion

19.1 General

Only Ex “o” equipment having a complete certificate shall be installed.

Ex “o” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Oil immersed equipment shall be installed in accordance with the manufacturer’s documentation.

NOTE Further installation details will be included in the next edition of IEC 60079-6 for transfer to the next edition of IEC 60079-14.

19.2 External connections

The external (field wiring) connections shall be protected with a type of protection meeting the EPL requirements of the location.

20 Additional requirements for type of protection “q” – Powder filling

Only Ex “q” equipment having a complete certificate shall be installed.

Ex “q” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Powder filled equipment shall be installed in accordance with the manufacturer’s documentation.

21 Additional requirements for type of protection “m” – Encapsulation

Only Ex “m” equipment having a complete certificate shall be installed.

Ex “m” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Encapsulated equipment shall be installed in accordance with the manufacturer’s documentation.

22 Additional requirements for type of protection “op” – Optical radiation

Only Ex “op” equipment having a complete certificate shall be installed.

Ex “op” devices and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Equipment with optical radiation shall be installed in accordance with the manufacturer’s documentation and Annex K.

23 Additional requirements for type of protection “t” – Protection by enclosure

Only Ex “t” equipment having a complete certificate shall be installed.

Ex “t” enclosures and components having only a component certificate, i.e. marked with a “U”, shall not be installed in the hazardous area unless part of an assembly of components (now being referred to as an equipment) when the components in the equipment are permitted by a full Ex certificate which may contain an “X” and the equipment label carries full Ex marking including temperature class.

Equipment type of protection “t” shall be installed in accordance with the manufacturer’s documentation and Annex L.

Annex A
(normative)

Knowledge, skills and competencies of responsible persons, operatives/technicians and designers

A.1 Scope

Annex A specifies the knowledge, skills and competencies of persons referred to in this standard.

A.2 Knowledge and skills

A.2.1 Responsible persons

Responsible persons who are responsible for the processes involved in the design, selection and erection of explosion protected equipment shall possess, at least, the following:

a) general understanding of relevant electrical engineering;
b) understanding and ability to read and assess engineering drawings;
c) practical understanding of explosion protection principles and techniques;
d) working knowledge and understanding of relevant standards in explosion protection;
e) basic knowledge of quality assurance, including the principles of auditing, documentation, traceability of measurement and instrument calibration.

Such persons shall confine their involvement to the management of competent operatives conducting selection and erection duties and not engage themselves directly in the work without ensuring their practical skills at least meet the requirements given in A.2.2.

A.2.2 Operatives/technicians (selection and erection)

Operatives/technicians shall possess, to the extent necessary to perform their tasks, the following:

a) understanding of the general principles of explosion protection;
b) understanding of the general principles of types of protection and marking;
c) understanding of those aspects of equipment design which affect the protection concept;
d) understanding of content of certificates and relevant parts of this standard;
e) general understanding of inspection and maintenance requirements of IEC 60079-17;
f) familiarity with the particular techniques to be employed in the selection and erection of equipment referred to in this standard;
g) understanding of the additional importance of permit to work systems and safe isolation in relation to explosion protection.

A.2.3 Designers (design and selection)

Designers shall possess, to the extent necessary to perform their tasks, the following:

a) detailed knowledge of the general principles of explosion protection;
b) detailed knowledge of the general principles of types of protection and marking;
c) detailed knowledge of those aspects of equipment design which affect the protection concept;

d) detailed knowledge of content of certificates and relevant parts of this standard;
e) understanding of practical skills for the preparation and installation of relevant concepts of protection;
f) detailed knowledge of the additional importance of permit to work systems and safe isolation in relation to explosion protection;
g) detailed knowledge of the particular techniques to be employed in the selection and erection of equipment referred to in this standard;
h) general understanding of inspection and maintenance requirements of IEC 60079-17.

A.3 Competencies

A.3.1 General

Competencies shall apply to each of the explosion protection techniques for which the person is involved. For example: it is possible for a person to be competent in the field of selection and erection of Ex "i" equipment only and not be fully competent in the selection and erection of Ex "d" switchgear or Ex "e" motors. In such cases, the person's management shall define this in their documentation system.

A.3.2 Responsible persons

Responsible persons shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.1 relevant to the types of protection and/or types of equipment involved.

A.3.3 Operatives/technicians

Operatives/technicians shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.2 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) use of documentation in 4.2;
b) production of reports, e.g. inspection reports, to the user as identified in 4.2;
c) practical skills necessary for the preparation and installation of relevant concepts of protection;
d) use and production of installation records as identified in 4.2.

A.3.4 Designers

Designers shall be able to demonstrate their competency and provide evidence of attaining the knowledge and skill requirements specified in A.2.3 relevant to the types of protection and/or types of equipment involved.

They shall also be able to demonstrate their competency with documentary evidence in the:

a) production of documentation specified in 4.2;
b) production of designers certificates to the user as identified in 4.2;
c) practical skills necessary for the preparation and compilation of relevant design details for the concepts of protection and systems involved;
d) updated and production of installation records as identified in 4.2.

A.4 Assessment

The competency of responsible persons, operatives and designers shall be verified and attributed, at intervals relevant to national regulations or standards or user requirements, on the basis of sufficient evidence that the person:

a) has the necessary skills required for the scope of work;

b) can act competently across the specified range of activities; and

c) has the relevant knowledge and understanding underpinning competency.

Annex B
(informative)

Safe work procedure guidelines for explosive gas atmospheres

A safe work procedure can be implemented to permit ignition sources to be used in a hazardous area under prescribed conditions.

A safe work permit can be issued when a specific location has been assessed to ensure that gas or vapour is not present and is not expected to be present, in quantities which may give rise to flammable concentrations, during a specified period. The permit may prescribe continuous or periodic gas monitoring and/or detailed actions to be taken in the event of a release.

Considerations for the issue of a safe work permit may include:

a) specifying the start date/time of the permit,
b) defining the location of the activity,
c) specifying the nature of the permitted activity (e.g. Diesel generator, drilling),
d) taking and possible recording measurements to confirm the absence of an ignitable concentration of any flammable gas or vapour,
e) specifying sampling requirements to confirm the continued absence of a flammable gas or vapour,
f) control of possible flammable gas or liquid sources,
g) specifying contingency plans for emergencies,
h) specifying the expiry date/time of the permit.

NOTE Important aspects associated with documentation, training, controls, and use required for an effective application of a safe work permit are beyond the scope of this standard.

Annex C
(normative)

Initial inspection –
Equipment-specific inspection schedules

NOTE Inspection schedules are derived from IEC 60079-17 for detailed inspections.

Tables C.1, C.2 and C.3 give equipment-specific inspection schedules.

Table C.1 – Inspection schedule for Ex "d", Ex "e", Ex "n" and Ex "t"

Check that:		Ex "d"	Ex "e"	Ex "n" Ex "t"
		Grade of inspection: Detailed		
A	**GENERAL (ALL EQUIPMENT)**			
1	Equipment is appropriate to the EPL/zone requirements of the location	X	X	X
2	Equipment group is correct	X	X	X
3	Equipment temperature class is correct (only for gas)	X	X	n
4	Equipment maximum surface temperature is correct			t
5	Degree of protection (IP grade) of equipment is appropriate for the level of protection/group/conductivity	X	X	X
6	Equipment circuit identification is correct	X	X	X
7	Equipment circuit identification is available	X	X	X
8	Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	X	X	X
9	There is no damage or unauthorized modifications	X	X	X
10	There is no evidence of unauthorized modification			
11	Bolts, cable entry devices (direct and indirect) and blanking elements are of the correct type and are complete and tight			
	– physical check	X	X	X
12	Threaded covers on enclosures are of the correct type, are tight and secured			
	– physical check	X		
13	Joint surfaces are clean and undamaged and gaskets, if any, are satisfactory and positioned correctly	X		
14	Condition of enclosure gaskets is satisfactory	X	X	X
15	There is no evidence of ingress of water or dust in the enclosure in accordance with the IP rating	X	X	X
16	Dimensions of flanged joint gaps are: – within the limits in accordance with the manufacturer's documentation or – within maximum values permitted by the relevant construction standard at time of installation or – within maximum values permitted by site documentation	X		
17	Electrical connections are tight		X	X
18	Unused terminals are tightened		X	n
19	Enclosed-break and hermetically sealed devices are undamaged			n
20	Encapsulated components are undamaged		X	n
21	Flameproof components are undamaged		X	n
22	Restricted breathing enclosure is satisfactory (type "nR" only)			n

	Check that:	Ex "d"	Ex "e"	Ex "n" Ex "t"
		Grade of inspection: Detailed		
23	Test port, if fitted, is functional (type "nR" only)			n
24	Breathing operation is satisfactory (type "nR" only)	X	X	n
25	Breathing and draining devices are satisfactory	X	X	n
	EQUIPMENT SPECIFIC (LIGHTING)			
26	Fluorescent lamps are not indicating EOL effects		X	X
27	HID lamps are not indicating EOL effects	X	X	X
28	Lamp type, rating, pin configuration and position are correct	X	X	X
	EQUIPMENT SPECIFIC (MOTORS)			
29	Motor fans have sufficient clearance to the enclosure and/or covers, cooling systems are undamaged, motor foundations have no indentations or cracks	X	X	X
30	The ventilation airflow is not impeded	X	X	X
31	Insulation resistance (IR) of the motor windings is satisfactory	X	X	X
B	**INSTALLATION – GENERAL**			
1	Type of cable is appropriate	X	X	X
2	There is no obvious damage to cables	X	X	X
3	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	X	X	X
4	Stopping boxes and cable boxes are correctly filled	X		
5	Integrity of conduit system and interface with mixed system maintained	X	X	X
6	Earthing connections, including any supplementary earthing bonding connections are satisfactory (for example connections are tight and conductors are of sufficient cross-section)			
	– physical check	X	X	X
7	Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	X	X	X
8	Automatic electrical protective devices are set correctly (auto-reset not possible)	X	X	X
9	Automatic electrical protective devices operate within permitted limits	X	X	X
10	Specific conditions of use (if applicable) are complied with	X	X	X
11	Cables not in use are correctly terminated	X	X	X
12	Obstructions adjacent to flameproof flanged joints are in accordance with IEC 60079-14	X		
13	Variable voltage/frequency installation complies with documentation	X	X	X
	INSTALLATION – HEATING SYSTEMS			
14	Temperature sensors function according to manufacturer's documents	X	X	t
15	Safety cut off devices function according to manufacturer's documents	X	X	t
16	The setting of the safety cut off is sealed	X	X	
17	Reset of a heating system safety cut off possible with tool only	X	X	
18	Auto-reset is not possible	X	X	
19	Reset of a safety cut off under fault conditions is prevented	X	X	
20	Safety cut off independent from control system	X	X	
21	Level switch is installed and correctly set, if required	X	X	
22	Flow switch is installed and correctly set, if required	X	X	
	INSTALLATION – MOTORS			

	Check that:	Ex "d"	Ex "e"	Ex "n" Ex "t"
		Grade of inspection: Detailed		
23	Motor protection devices operate within the permitted t_E or t_A time limits.		X	
C	**ENVIRONMENT**			
1	Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	X	X	X
2	No undue accumulation of dust and dirt	X	X	X
3	Electrical insulation is clean and dry		X	X

Table C.2 – Initial inspection schedule for Ex "I" installations

	Check that:	Grade of inspection: Detailed
A	**EQUIPMENT**	
1	Circuit and/or equipment documentation is appropriate to the EPL/zone	X
2	Equipment installed is that specified in the documentation	X
3	Circuit and/or equipment category and group correct	X
4	IP rating of equipment is appropriate to the Group III material present	X
5	Equipment temperature class is correct	X
6	Ambient temperature range of the apparatus is correct for the installation	X
7	Service temperature range of the apparatus is correct for the installation	X
8	Installation is clearly labelled	X
9	Enclosure, glass parts and glass-to-metal sealing gaskets and/or compounds are satisfactory	X
10	Cable glands and blanking elements are the correct type, complete and tight – physical check	X
11	There are no unauthorized modifications	X
12	There is no evidence of unauthorized modifications	X
13	Diode safety barriers, galvanic isolators, relays and other energy limiting devices are of the approved type, installed in accordance with the certification requirements and securely earthed where required	X
14	Condition of enclosure gaskets is satisfactory	X
15	Electrical connections are tight	X
16	Printed circuit boards are clean and undamaged	X
17	The maximum voltage U_m of the associated apparatus is not exceeded	X
B	**INSTALLATION**	
1	Cables are installed in accordance with the documentation	X
2	Cable screens are earthed in accordance with the documentation	X
3	There is no obvious damage to cables	X
4	Sealing of trunking, ducts, pipes and/or conduits is satisfactory	X
5	Point-to-point connections are all correct	X
6	Earth continuity is satisfactory (e.g. connections are tight, conductors are of sufficient cross-section) for non-galvanically isolated circuits	X
7	Earth connections maintain the integrity of the type of protection	X
8	Intrinsically safe circuit earthing is satisfactory	X

Check that:		Grade of inspection: Detailed
9	Insulation resistance is satisfactory	X
10	Separation is maintained between intrinsically safe and non-intrinsically safe circuits in common distribution boxes or relay cubicles	X
11	Short-circuit protection of the power supply is in accordance with the documentation	X
12	Specific conditions of use (if applicable) are complied with	X
13	Cables not in use are correctly terminated	X
C	**ENVIRONMENT**	
1	Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	X
2	No undue external accumulation of dust and dirt	X

Table C.3 – Inspection schedule for Ex “p” and “pD” installations

Check that:		Grade of inspection: Detailed
A	**EQUIPMENT**	
1	Equipment is appropriate to the EPL/zone requirements of the location	X
2	Equipment group is correct	X
3	Equipment temperature class or surface temperature is correct	X
4	Equipment circuit identification is correct	X
5	Equipment circuit identification is available	X
6	Enclosure, glasses and glass-to-metal sealing gaskets and/or compounds are satisfactory	X
7	There are no unauthorized modifications	X
8	There is no evidence of unauthorized modifications	X
9	Lamp type, rating, and position are correct	X
B	**INSTALLATION**	
1	Type of cable is appropriate	X
2	There is no obvious damage to cables	X
3	Earthing connections, including any supplementary earthing bonding connections, are satisfactory, for example connections are tight and conductors are of sufficient cross-section – physical check	X
4	Fault loop impedance (TN systems) or earthing resistance (IT systems) is satisfactory	X
5	Automatic electrical protective devices operate within permitted limits	X
6	Automatic electrical protective devices are set correctly	X
7	Protective gas inlet temperature is below maximum specified	X
8	Ducts, pipes and enclosures are in good condition	X
9	Protective gas is substantially free from contaminants	X
10	Protective gas pressure and/or flow is adequate	X
11	Pressure and/or flow indicators, alarms and interlocks function correctly	X
12	Conditions of spark and particle barriers of ducts for exhausting the gas in hazardous area are satisfactory	X

Check that:		Grade of inspection: Detailed
13	Specific conditions of use (if applicable) are complied with	X
C	**ENVIRONMENT**	
1	Equipment is adequately protected against corrosion, weather, vibration and other adverse factors	X
2	No undue accumulation of dust and dirt	X

Annex D
(informative)

Electrical installations in extremely low ambient temperature

D.1 General

Special precaution should be applied when selecting equipment for use in an arctic climate due to extremely low temperatures.

NOTE 1 The standard ambient temperature range is from –20 °C up to 40 °C. Equipment suitable for use outside the standard ambient temperature range is designed, tested, certified and marked accordingly.

NOTE 2 The objective of Annex D is to provide guidance in the proper design, selection and erection of equipment used in low ambient temperatures.

D.2 Cables

In the selection of cables for fixed installations, care should be taken with regard to the characteristics of the insulation material at extremely low temperatures. Special precaution should be taken for the service temperature and minimum bending radius of the cable at such low temperatures.

The installation of cables should be carried out at an appropriate ambient temperature range.

D.3 Electrical trace heating systems

Special precaution should be taken for the inrush current, the service temperature, the minimum bending radius and the thermal insulation properties of electrical resistance trace heaters at such low temperatures.

D.4 Lighting systems

D.4.1 General

Selection of luminaires should take into account that not all types of lamps will work under these temperatures.

D.4.2 Emergency lights

Selection of emergency lights should take into account that some batteries (e.g. NiCd batteries) cannot be charged at these temperatures.

D.5 Electrical rotating machines

Selection of electrical rotating machines should take into account the appropriate type for these low temperatures.

Annex E
(informative)

Restricted breathing test for cables

E.1 Test procedure

A piece of cable with a length of 0,5 m should be type tested when installed into a sealed enclosure of 5 l (± 0,2 l), under constant temperature conditions. The cable is considered acceptable if the time interval required for an internal overpressure of at least 0,3 kPa (30 mm water gauge) to drop by 0,15 kPa (15 mm water gauge) is not less than 5 s.

The enclosure must be completely tight to avoid pressure loss through the enclosure gaps.

Annex F
(informative)

Installation of electrical trace heating systems

F.1 General

Each electric trace heating system is designed to meet the requirements of the particular process and plant. Because each system comprises a number of components integrated at the site, it is necessary to ensure that the plant parameters on which the design is based are still valid when the trace heating system is installed, and also that the components are installed correctly. Appropriate testing and maintenance are essential in order to ensure satisfactory performance and safety.

F.2 Definitions

F.2.1 Electrical trace heating system

An electrical trace heating system is typically applied externally to equipment and primarily functions to maintain the temperature of contents in piping, tanks and vessels. In hazardous areas the electrical components of the trace heating system are required to be certified and the overall system designed, installed and checked so that it does not result in high temperatures which may become an ignition source.

The system also includes the appropriate marking according to IEC 60079-30-1 and to the system documentation (name plates or tags, operating manual, design documentation, certificates, etc.).

F.2.2 System components

System components consist of all components needed for the safe intended use of an electrical trace heating system. A complete electrical trace heating system typically consists of

– an electrical resistance trace heater unit (heating cable or pads);
– installation accessories, such as terminal enclosures, connectors and splice kits;
– temperature controllers and/or limiters;
– thermal insulation and weather barrier (cladding).

The electrical components shall either have separate certification or they shall be included in a heating system certificate.

F.2.3 Site-fabricated trace heaters

Site-fabricated trace heaters are permissible provided the trace heaters are certified for site-fabrication. In this case:

– the installation instructions supplied by the manufacturer will indicate this is allowable;
– installation personnel should be competent in the special techniques required;
– trace heater(s) should pass the field (site work) tests specified in IEC 60079-30-1:2007, Annex D;
– trace heater(s) should be marked in accordance with IEC 60079-0 and IEC 60079-30-1.

F.2.4 Location of sensors

The number and location of sensors are determined by the requirements of the process design criteria. Incorrect application and/or installation of the sensors will have a direct impact on the overall trace heating system performance. If the circuit information provided is not clear or does not match the installation, the provider of the circuit information should be contacted for clarification.

F.2.5 Thermal insulation

The installation of thermal insulation is a key component in the performance of an electrical trace heating system. Incorrect application and/or installation of the thermal insulation system will have a direct impact on the overall trace heating system performance. This includes the effect on temperature sensing devices and controls.

The type and thickness of the insulation and the type of insulation barrier or covering should be confirmed as specified in the design documentation.

F.2.6 Personnel aspects

Persons involved in the installation and testing of electric trace heating systems should be suitably trained in all special techniques required. Installation should be carried out under the supervision of a qualified person who has undergone supplementary training in electric trace heating systems for use in explosive atmospheres. Only trained personnel should carry out especially critical work, such as the installation of connections and terminations.

The installer should fulfill the skills/qualification requirements as defined in the installation instructions supplied by the manufacturer.

F.3 General requirements

The safety-relevant characteristics of electrical trace heating systems for use in explosive atmospheres, in particular the temperature class or maximum surface temperature, are dependent, in part, on the design and the installation of the trace heating system. IEC 60079-30-1 specifies the requirements for the design, testing, and certification of trace heating systems and further recommendations can be found in IEC 60079-30-2.

The temperature classification or maximum surface temperature of the trace heater will be specified by the manufacturer.

The marking plate, if supplied, should be fixed to the electrical trace heating system by the installer in accordance with the manufacturer’s instructions. Requirements for the explosion protection for electrical trace heating systems are dependent on the EPL, the equipment group and the temperature class or maximum surface temperature.

IEC 60079-30-1 does not permit the installation of electrical trace heating systems in EPL “Ga” or “Da”.

Depending on the type of electrical trace heating system used and the installation conditions, temperatures can vary and each system has to be treated individually. Limitations and requirements given in the certificate should be taken in consideration. It should be ensured that during installation all relevant requirements are fulfilled.

F.4 Requirements for EPL “Gb”, “Gc”, “Db” and “Dc”

F.4.1 General

According to IEC 60079-30-1, it is necessary to differentiate between “stabilized design” and “controlled design”.

F.4.2 Stabilized design

F.4.2.1 General

The electrical trace heating system is designed in such a way that, under all reasonably foreseeable conditions, the surface temperature of the electrical resistance trace heater does not exceed the limits of the temperature class or the maximum surface temperature, minus 5 K for temperatures lower than or equal to 200 °C or minus 10 K for temperatures higher than 200 °C.

NOTE Here the product classification or systems approach is applied. Thus, certification can state the temperature class or the maximum surface temperature. The manufacturer will supply the heating system parts with an instructions manual, design documentation and a marking plate.

F.4.2.2 PTC characteristic

Trace heaters that significantly reduce power with an increase in temperature can be assigned temperature classes by testing. In many applications further temperature limiting control measures are not necessary, provided that the temperature class of the trace heater is lower in temperature than that specified for the application. Nevertheless the limiter and stabilized design measures can be applied to operate the system in a narrower band of process temperatures.

F.4.2.3 Fixed condition

Stabilized design is based on the principle of determining the maximum workpiece and trace heater surface temperatures under a worst-case set of conditions. This is a calculation of the equilibrium conditions that occur when the heat input equals the system heat loss. The worst-case set of conditions include:

- maximum ambient temperature, typically assumed to be 40 °C unless otherwise specified;
- no wind (still air);
- use of a conservative or minimum value for the thermal conductivity of the thermal insulation;
- no temperature control as per the design or to simulate a failed temperature controller;
- the trace heater is operated at its stated operating voltage plus 10 %;
- the trace heater is assumed to be operating at the upper limit of the manufacturing tolerance, or at the minimum specific resistance for series trace heaters.

F.4.3 Controlled design

Controlled design applications require the use of a temperature control device to limit the maximum surface temperature. The temperature limiting device operates independently from the temperature controller. A protective device, such as a temperature limiter, de-energizes the system and prevents the temperature from exceeding the maximum permissible surface temperature. In the event of a fault or damage to a sensor, the heating system is de-energized in order to replace the defective equipment.

NOTE 1 The temperature class or maximum surface temperature of the electrical trace heating system is dependent on the layout (e.g. the fixed setting point of a monitoring device) and the correct installation (e.g. defining the “hot-spot” and the correct positioning of the temperature sensors). The manufacturer of the system issues precise instructions on the design, installation and the necessary qualifications of the installation personnel.

The “temperature monitoring” method can provide a false presumption of safety if not applied correctly. A temperature safety device, should be set to a lower limiting temperature than the maximum for the temperature class of the associated hazardous area, applying a relevant safety factor. No matter how the sensor of the safety device is mounted, there will always be an offset between the actual maximum surface temperature of the hottest point in the system and the set point of the safety device. This offset is usually considerable and is dependent on:

– the position of the sensor with respect to the electrical resistance trace heater geometry or position;
– the location of the sensor in the system;
– the hysteresis or control band of the protective device;
– the heat transfer between electrical resistance trace heater, sensor, work piece and environment.

NOTE 2 The temperature class or maximum surface temperature stated in the certificate of conformity is based on verified design calculations of the manufacturer that predict the offset between the set point of the limiter and the actual maximum surface temperature of the electrical trace heater in the system. In this case, the maximum surface temperature depends on the correct installation, correct location and position of the sensor and the incorporation of the applicable temperature offset in the set point of the safety device.

F.5 Design information

F.5.1 Design information drawings and documents

To ensure a workable electrical trace heating system design, the trace heating designer should be furnished with up-to-date piping information and should be notified of any revisions of items and drawings that pertain to the electrical trace heating system.

The following information, as applicable for the specific installation, is used in the design of the trace heating system:

a) thermal design parameters
b) system flow diagram
c) equipment layout drawings (plans, sections, etc.)
d) pipe drawings (plans, isometrics, line lists, etc.)
e) piping specifications
f) thermal insulation specifications
g) equipment detail drawings (pumps, valves, strainers, etc.)
h) electrical drawings (single line drawings, functional wiring diagrams, etc.)
i) bill of materials
j) electrical equipment specifications
k) equipment installation and instruction manuals
l) equipment details
m) thermal insulation schedules
n) area classification drawings
o) temperature class of gas or vapour involved or the maximum surface temperature for dust
p) process procedures that would cause elevated pipe temperatures, that is, steam out or exothermic reactions

F.5.2 Isometric or heater configuration line lists and load charts

Each heater circuit should be shown on a drawing depicting its physical location, configuration, and relevant data for the heating device and its piping system. The drawing and/or design data should include the following information:

a) piping system designation
b) pipe size and material
c) piping location or line number
d) heating device designation or circuit number
e) location of power connection, end seal, and temperature sensors as applicable
f) heating device number
g) heating device characteristics such as the following:
    1) temperature to be maintained
    2) maximum process temperature
    3) minimum ambient temperature
    4) maximum exposure temperature (when applicable)
    5) maximum sheath temperature (when required)
    6) heat-up parameters (when required)
    7) length of piping
    8) trace ratio of electrical resistance trace heater per length of pipe
    9) extra length of electrical resistance trace heater applied to valves, pipe supports, and other heat sinks
    10) length of electrical resistance trace heater
    11) operating voltage
    12) watt per unit length of electrical resistance trace heater at desired maintenance temperature
    13) heat loss at desired maintenance temperature per unit length of pipe
    14) watts, total
    15) circuit current
h) thermal insulation type, nominal size, thickness, and k-factor
i) area classification, including the temperature class or the maximum surface temperature for each area (if applicable)
j) bill of material
k) heat transfer aids
l) power distribution panel tag number or designation
m) alarm and control equipment designation and set points (including any offsets as specified)

F.6 Incoming inspections

F.6.1 Receiving materials

Upon receipt of trace heating system components, a general inspection should be conducted including a confirmation of the correct type and quantities of materials and documentation. All trace heaters should be checked to verify catalogue type, product and package markings, power rating, voltage rating, quantity and special characteristics. In addition, receipt of installation instructions and the certificates, as required, should be verified.

The supplier of the trace heating system is required to provide specific instructions for the trace heaters and the various types of system components. These instructions should be followed explicitly in order to maintain the system integrity and to meet the EPL and temperature class requirements.

F.6.2 Pre-installation testing

The following tests should be performed and documented on a pre-installation checklist and record similar to that of Table F.1. This should also be used to determine whether the trace heating circuit design matches the installation conditions:

a) Visual check for damage. Continuity and insulation checks should be made as a final check. Insulation resistance shall be measured in accordance with F.6.4.
b) Verify individual temperature controls to ensure the correct device has been provided in accordance with the design documentation. In addition the set points shall be verified.
c) General inspections of vendor fabricated and assembled control panels and documentation that all wiring, layout and functions are correct and have been tested. and that no damage has occurred in transit to site.

F.6.3 Visual examination

The trace heaters should be completely free of physical damage. Connections preassembled at the factory should be sufficiently rugged to withstand normally expected conditions during installation.

F.6.4 Insulation resistance test

Insulation resistance should be measured from the trace heater conductors to the electrically conductive covering with a minimum 500 V d.c. test voltage. However, it is recommended that higher test voltages be used. Mineral insulated trace heaters should be tested at, but not exceeding, 1 000 V d.c. and polymeric insulated trace heaters should be tested at 2 500 V d.c. The measured insulation resistance should not be less than 20 MΩ.

F.6.5 Component substitution

Component substitution includes the following limitations:

a) components specifically listed in the supplier’s installation or maintenance instructions should not be substituted with similar parts unless the components are part of the certification;
b) other components specified in the supplier’s installation or maintenance instructions may be substituted with any suitably rated component;
c) components that are part of a wiring system that supplies power to the trace heater may be substituted with any suitably rated component acceptable to the authority having jurisdiction.

F.6.6 Location of power supply

The power supply location should be determined and specified prior to installation of the trace heaters. The junction boxes should be mounted in such a way that the trace heater cannot suffer damage between the point at which it emerges from the insulation and the point of entry into the junction box.

Table F.1 – Pre-installation checks

Items to be checked		Remarks
1	Is the work piece fully erected and tested and all temporary supports removed? Is the surface to be heated free from sharp edges, weld spatter and rough surfaces?	Any welding or pressure testing after the installation of a trace heater could damage the device
2	Is the surface upon which the trace heater is to be applied normal steel or non-metallic?	If the surface is of polished stainless steel, very thin-walled or non-metallic, special precautions may be necessary
3	Do the items to be heated correspond in size, position, etc., with the design?	It is sometimes difficult to be sure that the correct work piece is being heated. A suitable line numbering system may be of assistance
4	Has it been specified that metallic foil be installed before the application of the trace heater?	This may be used to aid heat distribution
5	Has it been specified that metallic foil be installed after the application of the trace heater?	This may be used to prevent insulation from surrounding the trace heater or to aid heat distribution
6	Can flow of product under normal or abnormal conditions reach temperatures greater than those that the trace heater can withstand?	This would normally be covered in the design stage; however, further discussion with staff at the plant may show that incorrect or out-of-date information has been used
7	Is the trace heating system's most recent documentation (working drawings, designs, and instructions) available?	No change should be contemplated without reviewing the trace heating system documentation, as careful calculations are necessary to ensure safe operation
8	Can pipes or surfaces expand and contract so as to cause stress on any part of the trace heating system installation?	In this case precautions are necessary to avoid damage
9	Can sensors of temperature controllers be affected by external influences?	An adjacent heating circuit could affect the sensor
10	Is the trace heater to be spiralled or zig-zagged onto the work piece, according to the design?	Check design loading per unit length of pipe (or surface area) to determine if spiral or zig-zag application is necessary
11	Are cold leads, when fitted, suitable for contact with the heated surface?	If the cold lead is to be buried under the insulation, it needs to be able to withstand the temperature
12	Is the pipework hung from a pipe rack?	In this case, special precautions are required to ensure the weatherproofing of the insulation at points of suspension
13	Does pipework have its full complement of supports?	The addition of intermediate supports at a later stage could damage the heating system
14	Are sample lines/bleed lines, etc., at the plant but not on drawings?	These could obstruct or prevent the fitting of the trace heater, and a review of the trace heating system documentation may be necessary
15	Are other parameters used in the design of the equipment, such as pipe supports, specified by the design documentation?	
16	Are the trace heaters, controllers, junction boxes, switches, cable glands, etc., suitable for the explosive gas atmosphere classification and the environmental conditions and are they protected as necessary against corrosion and the ingress of liquids and particulate matter?	

F.7 Installation of trace heaters

F.7.1 General

Attention shall be given to the supplier's minimum bending radii and any restrictions on installation such as overlap or cross-over.

In the installation of trace heating systems, only genuine components may be used. Otherwise the system certification will not apply.

The installation record shown in Table F.2 should be filled in and retained[1].

F.7.2 Connections and terminations

F.7.2.1 General

All types of trace heaters should be terminated correctly. Connections and terminations completed at the worksite should carefully follow the supplier's instructions. Factory terminated equipment should be inspected to ensure that such terminations are complete, properly tagged and/or marked in conformity with IEC 60079-0 and IEC 60079-30-1. The installer should review the certifications, the temperature ratings of the connections and terminations, and their suitability for the operating conditions.

Series resistance trace heaters intended for site termination should be checked before installation to ensure that the installed lengths correspond to the design length and loading. When mineral insulated trace heaters are terminated at the job site, the cut ends should be sealed immediately to prevent any moisture ingress. For parallel circuit trace heaters, the total circuit length should not exceed the supplier's recommendations.

F.7.2.2 Connection kits

The connection kits of a trace heater should be securely fitted in accordance with the supplier's instructions, protected to prevent physical damage, and positioned to prevent the ingress of water or other contaminants that could adversely affect its use or suitability.

F.7.2.3 Junction boxes

Trace heating circuits should be connected into boxes that are certified for the appropriate methods of protection and that have suitable ingress protection. Junction boxes should be located as closely as possible to the trace heater exit point while allowing for any work piece expansion. Junction box lids should not be left open at any time.

F.7.2.4 Cold leads

Checks should be made to ensure that the joints are waterproof, where applicable, and the bond to earth is valid. Cold leads, if used, should always emerge from the surrounding thermal insulation in such a way that ingress of water or other contaminants is not possible. Cold leads should be protected where they exit through thermal insulation.

Cold leads should be fitted or modified on site only in strict accordance with the supplier's instructions and conditions of use as specified by the certifications. Where cold leads have been jointed to metallic sheathed trace heaters by means of soldering or brazing, neither the trace heaters nor the cold lead should be bent near a brazed joint.

F.7.2.5 Trace heater entries and glands

Conductor terminations (see F.7.3) should not be completed until after all other connections and the end termination have been assembled and the circuit insulation resistance test (see F.6.4) is conducted.

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1 Derived from Table D of 60079-30-1:2007.

F.7.2.6 Jointing, splicing and modifications

Jointing, splicing and modifications to the trace heater should be carried out on site only in strict accordance with the supplier's instructions. Any such work on trace heaters may invalidate the certification. This applies particularly to any modifications to trace heaters where any change in unit length will alter the power density of the trace heater and affect the sheath temperature. Modifications should be recorded in the system documentation.

F.7.2.7 End terminations

The end termination of a trace heater should be securely fitted in accordance with the supplier's instructions and protected to avoid mechanical damage and the ingress of water or other contaminants that may adversely affect its use or suitability.

F.7.3 Conductor terminations

Terminals should be of sufficient size and rating to accept the conductors, which may be solid or stranded wires or foils. Care should be taken in stripping back insulation to avoid damaging the conductors.

Crimp or compression type connectors and ferrules should be of the correct size and of an approved type for the conductor concerned. Compression tools shall be suitable for the specific types of fittings and be in good condition.

Trace heaters that have been installed and not terminated should be sealed to prevent ingress of moisture and should be protected from damage pending completion of the termination.

F.8 Installation of control and monitoring equipment

F.8.1 Verification of equipment suitability

The selected limiters, controllers, thermostats, sensors, and related devices should meet the requirements of the overall system with regard to the service temperature, the IP (international protection) rating, and the method of protection. The certification of trace heating systems may prescribe the use of specific components. In these cases it is mandatory to use only parts specified by the manufacturer.

F.8.2 Sensor considerations

F.8.2.1 General sensor installation

The sensor should be installed and positioned in accordance with the supplier's instructions. The control sensor should not be situated in areas of external radiant heat, solar gain, process heat discharge or close to a heated building. Care should be exercised to ensure that the sensor can sense appropriate temperature conditions within a trace heated zone and away from the end of a pipe or a pipe support. Ambient temperature-sensing controllers should be sited in the most exposed position for the installation.

The sensor should be strapped in good thermal contact with the work piece or equipment and protected so that thermal insulation cannot be trapped between the sensor and the heated surface. Care should be taken not to damage the capillary tube, thermocouple or RTD leads, or to distort the sensor and thereby cause calibration error.

Where direct medium temperature sensing is required, the sensor should be located in thermowells at suitable positions, for example above potential sludge levels in vessels.

Excess capillary tube may be run under the thermal insulation unless the overall length exceeds 1 m, in which case the volume of the capillary may be such as to affect the calibration adversely.

Care should be taken to ensure that the capillary tube, thermocouple or RTD leads emerge from the thermal insulation in a manner that will not allow the ingress of moisture.

In many cases the sensor location is defined during the system design phase. Considerations for sensor placement are defined in F.8.2. Subclauses F.8.2.2 to F.8.3 describe installation considerations for specific installation methods.

F.8.2.2 Sensor installation for temperature controller

The sensor for the temperature controller is installed onto the surface of the work piece or equipment in a position that will provide a temperature representative of the overall circuit. As illustrated in Figure F.1, the sensor should be positioned so as not to be influenced by the temperature of the trace heater, or other factors such as heat sinks and solar gain.

F.8.2.3 Sensor installation for temperature limiting device

The sensor for the temperature limiting controller is installed onto the surface of the work piece or equipment in a position that will provide a temperature representative of the overall circuit. In order to ensure that the safety temperature controller can accurately react to the maximum trace heater sheath temperature. Particular attention should be paid to the location, method of attachment and set point. This method of sensor installation is based on the known relationship between the equipment temperature and the heater sheath temperature at a given power output. Typical temperature limiting sensor installation is indicated in Figure F.1.

The controller should be set such that the heater sheath temperature does not exceed the high-limit temperature under worst-case conditions (e.g. voltage +10 %, trace heater at upper limit of manufacturing power tolerance, heater out of contact with the work piece/equipment, high ambient temperature, no external convection).

For trace heater circuits that are designed for use with voltage regulating devices, it may be necessary to install the sensors using the methods described in F.8.2.3, F.8.2.4 and F.8.2.5. These methods respond quickly to rapid changes in heater sheath temperatures caused by failure of the voltage control device.

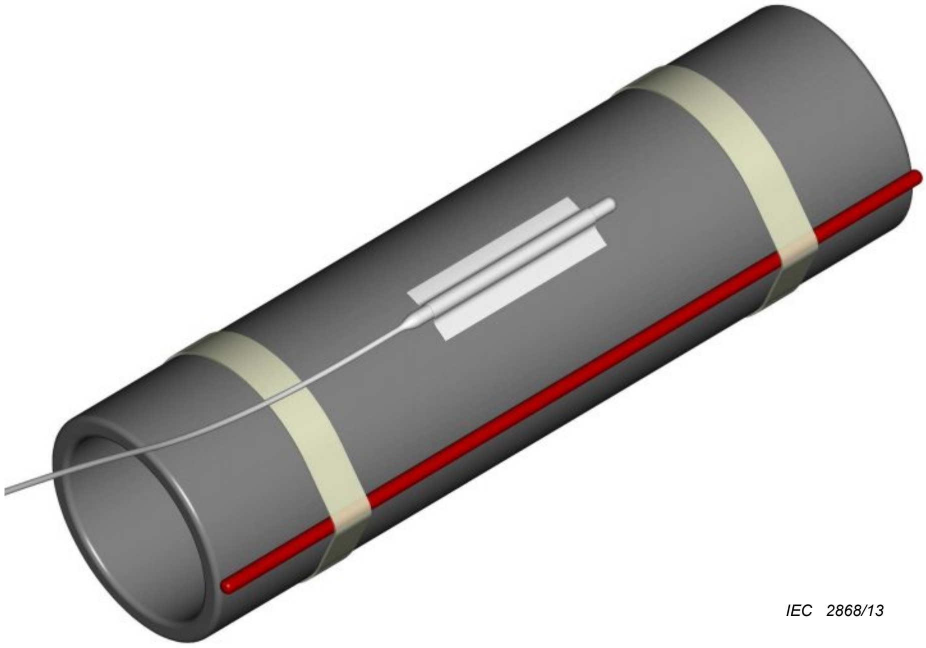


Figure F.1 – Typical installation of control sensor and sensor for temperature limiting control

F.8.2.4 Temperature limiting device with sensor on trace heater sheath

In Figure F.2, the temperature sensor is mounted directly to the trace heater and the trace heater is in direct contact with the surface being heated. To ensure accurate thermal coupling with the trace heater, it is necessary to install the sensor with metallic foil tape or heat transfer compound.

The location should be verified to be representative of the hottest point. The means to secure the sensor to the heater fixings should ensure the sensor cannot loosen with time and temperature exposure, and that the sensor will not be loosened during future maintenance operations.

This method of sensor installation does not measure the hottest part of the trace heater (which probably occurs at a point of no contact with the equipment). It should only be used with a controller setting that is below the high-limit temperature.

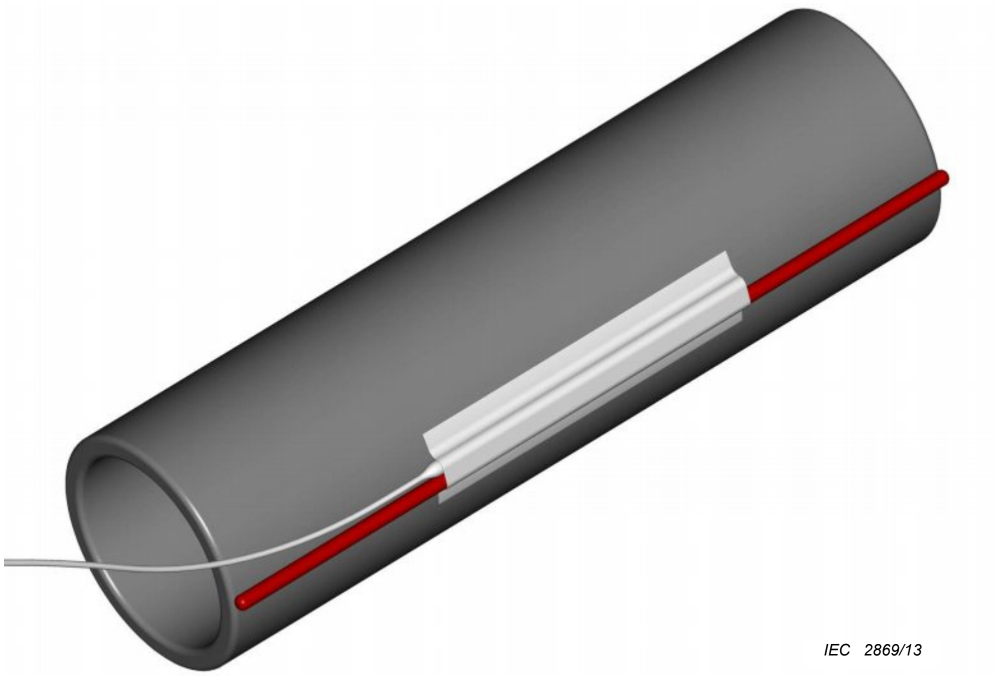
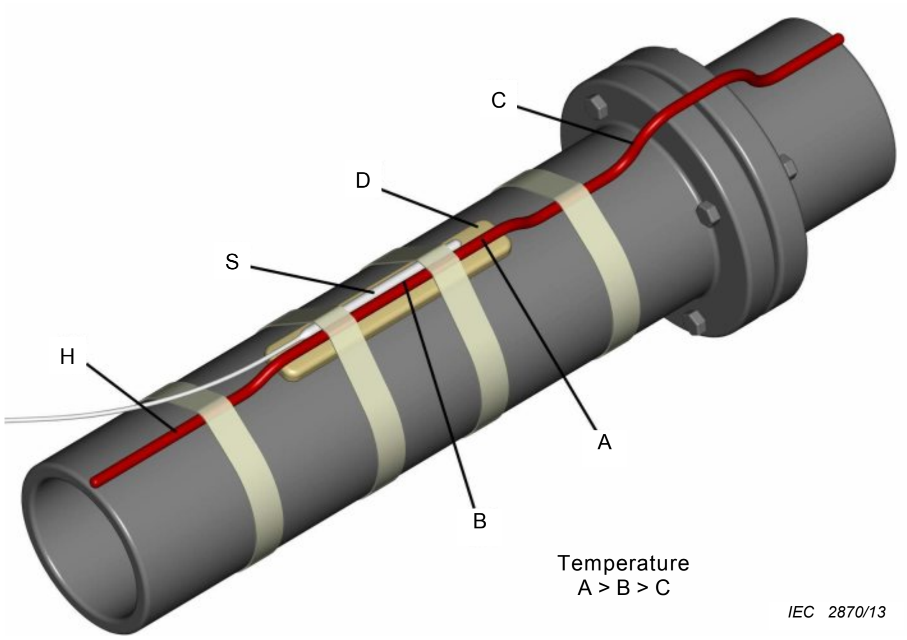


Figure F.2 – Limiting device sensor on sheath of trace heater

F.8.2.5 Temperature limiting device with artificial hot spot

In Figure F.3, the sensor is located to measure an artificial hot spot intending to represent the hottest point of the trace heater. This may be a suitable alternative method when used with series trace heaters.

In cases where the method in F.8.2.4 cannot reliably be utilized to coordinate with the system's worst case sheath temperature, the artificial hot spot method can provide some additional margin of safety. In this case thermal insulation is inserted between the trace heater and the surface being heated. The sensor for the temperature limiter is then installed in direct contact with the trace heater.



Key

H	trace heater	B	temperature at measurement point
S	temperature sensor	C	point with poor thermal coupling (characteristic hot spot)
A	temperature of artificial hot spot	D	thermal insulation between trace heater and heated surface

Figure F.3 – Limiting device sensor as artificial hot spot

To ensure that the temperature at the artificial hot spot is higher than the trace heater temperature at the point with poor thermal coupling (temperature C), the thermal insulation is about twice as long as the sensor. Because of the unavoidable heat dissipation of the sensor itself, the measured temperature B is indeed higher than temperature C, but lower than the actual temperature of hot spot A. This variance, which is a function of the ratio of the masses of the sensor and the trace heater (ratio of the diameters) and of the specific heating capacity (W/m), is taken into account in the limiter's temperature setting.

The advantage of this method is its extremely short reaction time to malfunctions such as controller failure, failure of the voltage control device, or overvoltage. In some cases it may be necessary to divide complex circuits into multiple circuits with individual temperature limiters.

F.8.3 Controller operation, calibration, and access

The settings of the temperature controllers and safety temperature limiters should be reviewed during commissioning. Depending on the setting possibilities offered by the safety temperature limiters, the limiters should be sealed against tampering.

The temperature control device and sensor loop should be calibrated at commissioning. The controller should be set to the required temperature and re-calibrated from the factory setting if necessary. A function check should be made by adjusting the temperature setting until the controller is seen to energize the trace heater.

All measured data should be documented.

F.9 Installation of thermal insulation system

F.9.1 General

The selection and application of the thermal insulation are key elements in the installation of an electric trace heating system. The thermal insulation is normally designed in such a way that it largely compensates the heat losses of the heating system. Consequently, problems with the insulation have a direct effect on the performance of the system as a whole. Minimization of energy dissipation reduces the running costs, improves the system characteristics and enhances the system's heating capacity. Installation of thermal insulation should conform to all applicable national standards and local regulations.

F.9.2 Preparatory work

Precautions should be taken to protect trace heaters from mechanical damage and moisture intrusion after they have been installed and prior to the application of thermal insulation. Before starting the installation of thermal insulation, it is recommended that site engineering establish a liaison between the trace heaters installer and the thermal insulation contractor, so that the thermal insulation is applied as soon as possible after the installation and testing of trace heaters. The installed trace heating system should have been tested in accordance with F.6.2.

The following checks and procedures should be confirmed:

a) Verify that the type, inside diameter, and thickness agree with the values used in selection of the trace heater(s). If the insulation thickness differs from the specification, the specified design temperatures will not be met.
b) For thermal insulation, temporary weather protection should be provided during storage, handling and installation to avoid the risk of moisture being trapped under the weather-protective coating or jacket.

F.10 Installation of distribution wiring and coordination with branch circuits

F.10.1 General

The branch circuit wiring of each trace heater circuit requires an over-current protective device. The size and type of distribution wiring, and the ratings of the branch circuit protective devices should be based on heater start-up currents and their duration at the minimum temperature the trace heater may experience.

F.10.2 Tagging/identification

The requirements of IEC 60079-30-1 include permanent tagging and identification which should be verified including:

a) circuit identification
b) monitor and alarm apparatus
c) trace heater power connection
d) circuit number and set point for each temperature controller

on the respective junction box.

F.11 Final installation review

F.11.1 Necessary modifications

The trace heating systems are subjected to checking of the maximum sheath temperature. If the temperatures measured deviate from the admissible sheath temperatures or from the design figures, corrective measures should be taken and the system design should be re-validated if necessary.

F.11.2 Field (site work) circuit insulation resistance test

The test procedure from F.6.2 should be conducted on all trace heater circuits after installation, with the requirement that the measured insulation resistance should not be less than 5 MΩ.

F.11.3 Visual inspection

The visual inspection should ensure that:

a) no moisture can penetrate the insulation as a result of weathering (correct position of overlaps or lock beading);
b) sliding connections (or the like) on weather cladding are sufficiently flexible to absorb any expansion movement;
c) the screws selected for fastening the weather cladding are short enough to exclude any possibility of damage to trace heaters or to temperature sensors;
d) the entry cut outs in the weather cladding for trace heaters, temperature sensors, etc., are dimensioned so as to render contact impossible. Especially in the case of branches, the cladding should be cut sufficiently wide;
e) the cladding joints and thermal insulation entries are properly sealed with an elastic, non-hardening sealant that is resistant to chemical attack and decay, and is dimensionally stable.

F.12 Commissioning

F.12.1 Pre-commissioning check

The pre-commissioning checklist given in Table F.1 should be completed and retained.

F.12.2 Functional check and final documentation

F.12.2.1 General

The trace heating system(s) should be commissioned after the thermal insulation has been installed and the electrical distribution is completed. The trace heater installation record given in Table F.2 should be completed and retained.

F.12.2.2 Functional check

The following functional checks should be conducted:

a) Close all branch circuits and verify proper current. A temporary bypass may be required for the temperature control device.
b) Verify that monitor or alarm circuits are operable. A bypass may be required at field contacts.
c) Fill out the trace heater commissioning record Table F.2 for each circuit. This shall clearly document all testing and commissioning data.
d) Record the electrical insulation resistance values for each measurement taken according to the procedure given in F.6.4.
e) Record the applied voltage and resulting current after 5 min of energization, and work piece temperature if required.
f) Verify that the alarm and monitor components operate as intended.

g) Verify that the calibration check at the temperature controller set point has been performed and the controller has been set at this value.

F.12.2.3 Final documentation

Adequate and uniform documentation of the electric trace heating circuits should be considered as a precondition for economical maintenance of this equipment. This is especially important to facilitate rapid troubleshooting in the event of circuit problems. It also provides the basis for simpler, faster and less costly handling of any desired modifications and expansions by a specialist for electric trace heating systems.

Considering electric trace heating systems in explosive gas atmospheres, the form of the project documentation is normally specified in detail in the respective system description.

The documentation of each heating circuit of a trace heating system should include the following elements:

a) Design and testing documentation:
   1) table of contents
   2) piping layout showing the trace heating circuits and the location of power points, connections, splices, tees, end terminations, and temperature sensors for control and limitation
   3) for vessels: layout of the trace heating circuits
   4) work piece and insulation list
   5) individual circuit length of trace heaters
   6) calculation and dimensioning data
   7) material list
   8) trace heater installation instructions
   9) heater cabling plan
   10) description of and installation instructions for temperature sensors
   11) electrical trace heating system installation record (Table F.2)
   12) temperature profile measurement
   13) installation certificate
b) Circuit diagrams or lists:
   1) wiring and circuit diagrams or lists
   2) terminal connection diagrams, switchgear with parts list
   3) installation instructions
c) Other:
   1) technical descriptions and instruction manuals for the individual pieces of equipment
   2) functional diagram as agreed to with the design engineer
   3) certificates of conformity for explosion protected equipment

Table F.2 – Electrical trace heating systems installation record – Example

Location	System	Project number	Reference drawing(s)
Line number	Trace heater number	Area classification	Temperature classification
Panel number	Location	Circuit number	Circuit amp/voltage
Trace heater manufacturer	Trace heater model	Trace heater wattage unit length/voltage rating	
Verify certification marking:			
Megohmmeter manufacturer/model		Voltage setting	Accuracy/full scale
Megohmmeter date of last calibration			
Multimeter manufacturer/model	Ohm setting	Accuracy/full scale	
TRACE HEATER TESTING	Test value/remarks	Date	Initials
Continuity test on self-regulating trace heater only used for short or open circuit. Minimum acceptable insulation resistance shall be 20 MΩ, except that for #4 for MI trace heaters the minimum is 5 MΩ. Minimum acceptable test voltage is 500 V d.c. However, 1 000 V d.c. recommended for MI, 2 500 V d.c. for polymeric trace heaters.			
1 Receipt of material on reel			
Continuity test on reel			
Insulation resistance test on reel			
2 Piping completed (approval to start trace heater installation)			
3 Trace heater installed (approval to start thermal insulation installation)			
Trace heater correctly installed on pipe, vessel or equipment			
Trace heater correctly installed at valves, pipe supports, other heat sinks			
Components correctly installed and terminated (power, tee-end seal)			
Installation agrees with manufacturer's instructions and circuit design			
4 Thermal insulation installation complete			
Continuity test			
Insulation resistance test			
SYSTEM INSPECTED			
5 Marking, tagging and identification complete (see IEC 60079-30-1, Clause 6)			
6 Trace heater effectively earthed			
7 Temperature controls properly installed and set points verified			
8 Junction boxes all certified and closed			
9 Thermal insulation weather tight (all penetrations sealed)			
10 End seals, covered splices marked on insulation outer cladding			
11 Drawings, documentation marked as-built			
Performed by:		Company	Date
Witnessed by:		Company	Date
Accepted by:		Company	Date
Approved by:		Company	Date

Annex G
(normative)

Potential stator winding discharge risk assessment – Ignition risk factors

Table G.1 – Ignition risk factors

Characteristics	Value	Factor
Rated voltage	> 11 kV	6
	> 6,6 kV to 11 kV	4
	> 3,3 kV to 6,6 kV	2
	> 1 kV to 3,3 kV	0
Average starting frequency in service	> 1 / hour	3
	> 1 / day	2
	> 1 / week	1
	≤1 / week	0
Time between disassembly, cleaning and examination of windings	> 10 years	3
	> 5 to 10 years	2
	> 2 to 5 years	1
	< 2 years	0
Degree of protection (IP code)	< IP44 [a]	3
	IP44 and IP54	2
	IP55	1
	> IP55	0
Environmental conditions	Very dirty and wet [b]	4
	Coastal outdoor [c]	3
	Outdoor	1
	Clean and dry indoor	0

[a] Only in clean environments and regularly serviced by trained personnel

[b] "Very dirty and wet" locations include those that may be subjected to deluge systems or comprise open deck on offshore locations.

[c] Exposed to atmospheres containing salt.

Annex H
(normative)

Verification of intrinsically safe circuits with more than one associated apparatus with linear current/voltage characteristics

H.1 General

The capacitance and inductance parameters for the system of intrinsically safe circuits shall be determined from the ignition curves of IEC 60079-11 using the system values of U_o and I_o under fault conditions and at each point in the system. The faults in accordance with IEC 60079-11 shall be applied to the electrical system as an entity and not to each item of electrical equipment.

The above requirements can be met by using the following calculation procedures.

H.2 Intrinsic safety with level of protection “ib”

The level of protection shall be deemed to be “ib” even if all the associated apparatus is level of protection “ia”.

NOTE This level of protection reduction takes account of the fact that the assessment is by calculation only without any test.

a) Determine the highest voltage and current in the system using the U_o and I_o values stated on the associated apparatus (see Annex I).
b) Check that the highest system current (I_o) multiplied by a safety factor of 1,5 does not exceed the current obtained from the ignition curves for resistive circuits, for the appropriate apparatus group in IEC 60079-11 for the maximum system voltage (U_o).
c) The maximum permissible inductance (L_o) is obtained from the ignition curves for inductive circuits, for the appropriate apparatus group in IEC 60079-11, using the highest system current (I_o) multiplied by a safety factor of 1,5.
d) The maximum permissible capacitance (C_o) is obtained from the appropriate ignition curve for capacitive circuits in IEC 60079-11, using the highest system voltage (U_o) multiplied by a safety factor of 1,5.
e) Check that the maximum permissible values of C_o and L_o conform to the requirements of 16.2.4.3.
f) Check that U_o, I_o and P_o (where $P_o = I_o U_o/4$) conform to the requirements of 16.2.4.3.
g) Determine the apparatus group of the system, in accordance with 16.2.4.3, taking into account the apparatus group of the ignition curves used.
h) Determine the temperature class of the system in accordance with 16.2.4.3 (where $P_o = I_o U_o/4$).

H.3 Intrinsic safety with level of protection “ic”

A similar calculation method may be used for “ic” circuits. The safety factor used shall be unity.

Annex I
(informative)

Methods of determining the maximum system voltages and currents in intrinsically safe circuits with more than one associated apparatus with linear current/voltage characteristics (as required by Annex H)

I.1 Intrinsically safe circuits with linear current/voltage characteristics

In the case of two or more items of associated apparatus in an intrinsically safe circuit (see 16.2.4.4), the following practical method can be used to determine the new maximum system voltages and currents under fault conditions in the intrinsically safe circuit using the values U_o, I_o of each item of associated apparatus taken from the documentation or from the marking plate.

Dependent on the interconnection of the intrinsically safe terminals of the associated apparatus, the values of U_o and I_o should be determined, in the case of normal operation and also under fault conditions, taking into account

– the summation of voltages only,

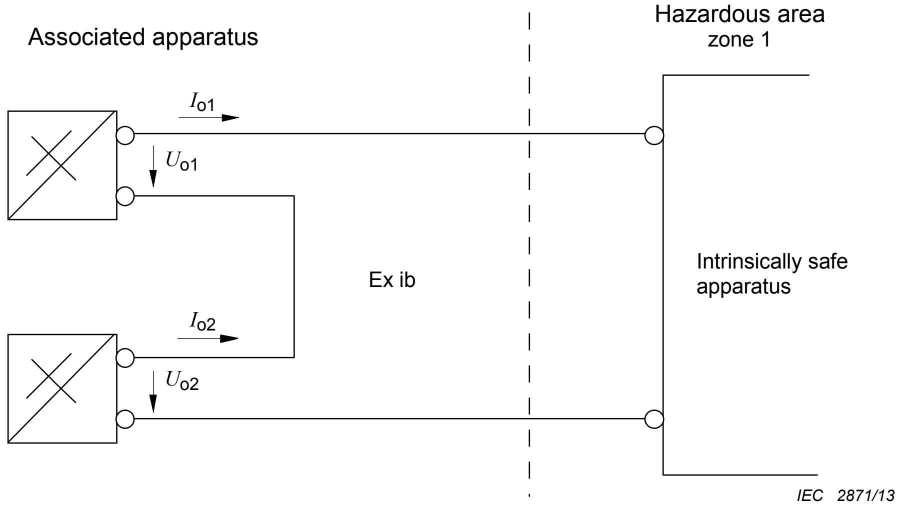
– the summation of currents only, or

– the summation of both voltages and currents.

In the case of series connection of the associated apparatus with galvanic isolation between intrinsically safe and non-intrinsically safe circuits (see Figure I.1) only the summation of voltages is possible, irrespective of the polarity of the circuits.

In the case of parallel connection of both poles of the sources (see Figure I.2) only the summation of currents is necessary.

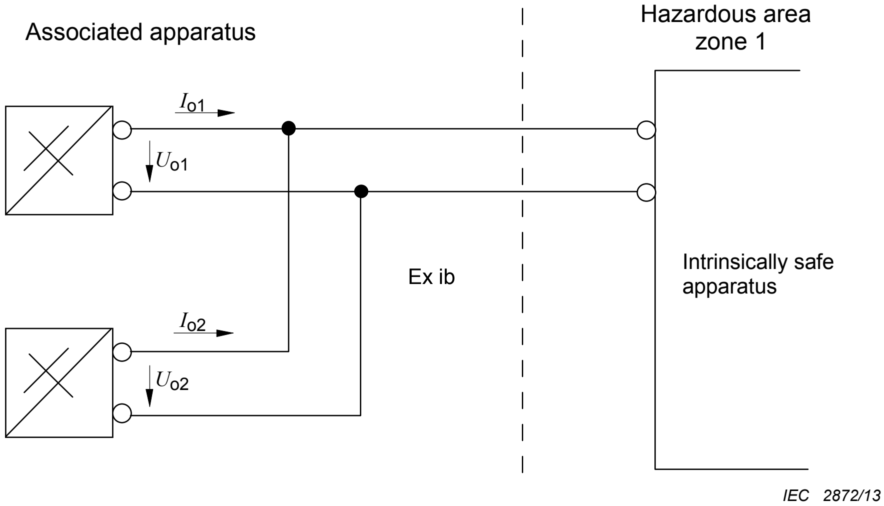
In all other cases, where any interconnection of the poles of the sources is possible (see Figure I.3) series or parallel connections have to be taken into account, dependent on the fault under consideration. In this situation, both the summation of voltages and the summation of currents have to be considered separately.



New maximum system values: $U_o = \Sigma\, U_{oi} = U_{o1} + U_{o2}$

$I_o = \max. (I_{oi})$

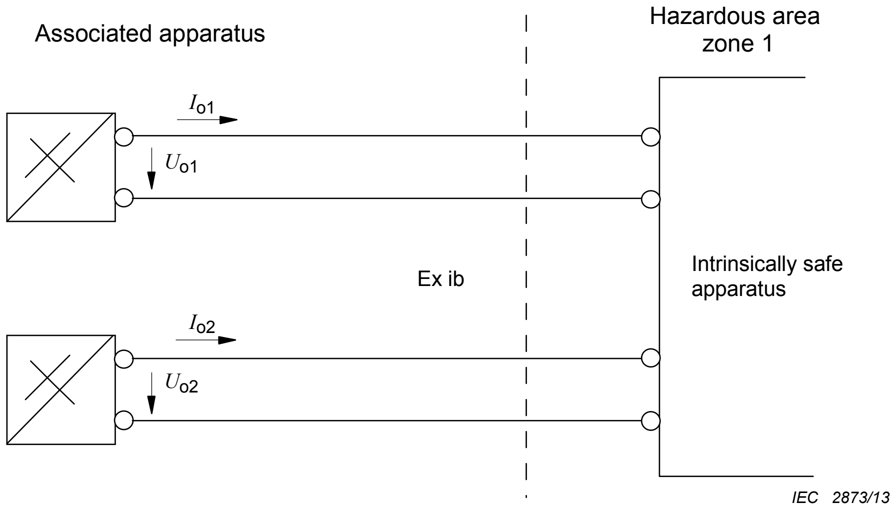
Figure I.1 – Series connection – Summation of voltage



New maximum system values: $U_o = \max. (U_{oi})$

$I_o = \Sigma\, I_{oi} = I_{o1} + I_{o2}$

Figure I.2 – Parallel connection – Summation of currents



New maximum system values: $U_o = \Sigma\, U_{oi} = U_{o1} + U_{o2}$ U_o = max. (U_{oi})

or

I_o= max. (I_{oi}) $I_o = \Sigma\, I_{oi} = I_{o1} + I_{o2}$

Figure I.3 – Series and parallel connections – Summations of voltages and summations of currents

I.2 Intrinsically safe circuits with non-linear current/voltage characteristics

Special consideration shall be given to situations where there is more than two associated apparatuses of which one or more of the associated apparatus has non-linear outputs. Such situations should receive careful consideration by a competent person. See IEC 60079-25 for further details.

Annex J
(informative)

Determination of cable parameters

J.1 Measurements

The inductance and capacitance of a cable should be measured using equipment operating at a frequency of 1 kHz ±0,1 kHz and an accuracy of ±1 %. The resistance of the cable should be measured using d.c. equipment with an accuracy of ±1 %. Results taken from a representative sample of cable with a minimum length of 10 m are acceptable. Measurements should be taken at an ambient temperature of 20 °C to 30 °C.

The equipment for the measurement of inductance should be able to operate satisfactorily when measuring low inductance in the presence of significant resistance.

Where practicable, measurements of all the possible combinations of the cores which can result from open-circuiting and short-circuiting the separate ends of the cables should be made. The maximum measured values of capacitance, inductance and the L/R ratio should be used as the cable parameters. Where there are a large number of cores, measurements should only be made utilizing a representative sample of the combination of cores which will create the largest values of inductance and capacitance.

The maximum capacitance of the cable should be determined by open-circuiting the remote end of the cable and measuring the capacitance of the combinations of the wires and screens which give the maximum value. For example, if a twin-pair screened cable is being measured, then the highest value will probably be measured between one core connected to the screen and the other core. That this is the highest value of capacitance should be confirmed by measuring the other combination of cores and screen.

The maximum inductance should be measured by connecting together the remote ends of the two cores which are spaced furthest from one another. The d.c. resistance of this path is the resistance used in calculating the L/R ratio of the cable.

Where the cable is loosely constructed, bending and twisting the cable a minimum of ten times should not cause the cable parameters to vary by more than 2 %.

For the purpose of these measurements, the combination of faults which could connect separate conductors in series to effectively increase the length of cables should not be considered. When measuring capacitance, any screens or unused cores should be joined together and connected to one side of the circuit being measured.

J.2 Cables carrying more than one intrinsically safe circuit

J.2.1 General

Where the conductors utilized by a particular intrinsically safe or energy-limited circuit are readily identifiable within a cable carrying more than one intrinsically safe circuit, only the cable parameters related to those specific conductors should be considered.

J.2.2 Type A cables

When all the conductors utilized in a circuit are within one screen, only the interconnections of the conductors within that screen and to that screen should be considered. Where the conductors are within more than one screen, measurement should be made utilizing all the relevant conductors within the relevant screens.

J.2.3 Type B cables

When the conductors utilized for a particular circuit can be clearly identified, measurement should be made only on those conductors. Where a clear identification cannot be made, all the possible combinations of the conductors used in that particular intrinsically safe circuit should be considered.

J.2.4 Type C cables

Measurement should be made on all conductors and any screens associated with the intrinsically safe systems which can be interconnected by the two short-circuit faults which have to be considered.

Where relevant conductors are not clearly identifiable, the testing should be extended to the possible combinations of the total number of conductors and screens associated with the three interconnected circuits.

J.3 FISCO

The effective capacitance of the bus cable results from the capacitance per meter C' for the capacitance between the two conductors. If the cable contains a screen an additional capacitance per meter needs to be considered.

The calculation of the capacitance depends on the electrical connection of bus cable and screen. If the bus circuit is isolated from the earthed screen or if the screen is arranged symmetrically between the plus and minus of the supply unit (Fieldbus balanced about ground), not only the capacitance conductor/conductor but also the series capacitance from the conductor/screen and screen/conductor is to be allowed for. The following is obtained

C' = C'conductor/conductor + 0,5C'conductor/screen

If the screen is connected with one pole of the supply unit, the following relation will result:

C' = C'conductor/conductor + C'conductor/screen

Annex K
(normative)

Additional requirements for type of protection "op" – Optical radiation

K.1 General

Where an enclosure is fitted with a light transmitting part, any optical radiation escaping from the enclosure shall be "op is".

K.2 Inherently safe optical radiation "op is"

K.2.1 General

Inherently safe optical radiation means radiation that is incapable of supplying sufficient energy under normal or specified fault conditions to ignite a specific explosive atmosphere. The concept is that beam strength is limited to below that required for ignition.

Ignition by optically irradiated particles in the air requires an amount of energy, power, or irradiance to be absorbed by the particle. The inherently safe concept applies to unconfined radiation or radiation inside optical equipment.

K.2.2 Change of cross sections

Reduction of the cross section of optical cables used in the installation is not permitted.

K.2.3 Coupler

The connection of optical cables in an optical coupler shall be made in such a way, that no additional energy can be introduced into the optical fibres.

K.3 Protected optical radiation "op pr"

K.3.1 General

This concept requires radiation to be confined inside the optical fibre or other transmission medium and is based on the assumption that there is no escape of radiation from the transmission medium. In this case the performance of the transmission medium defines the safety level of the system.

The risk analysis provides the safety requirements based on postulated conditions (fault conditions or normal operation).

Optical fibre may be used for situations where there are no postulated conditions such that an external force may cause a break of the protective barrier. Additional protective means (e.g. robust cabling, conduit or raceway) shall be used when external forces may cause a break during normal or abnormal operations. The risk analysis will dictate the protective measures required to prevent a break and escape of radiation.

NOTE The optical fibre protects the release of optical radiation into the atmosphere during normal operating conditions. For foreseeable malfunctions this can be provided by additional armouring, conduit, cable tray, or raceway.

K.3.2 Radiation inside enclosures

Incendive radiation inside enclosures is acceptable if the enclosure complies with a recognised type of protection for electrical equipment where an ignition source may be present inside the enclosure, i.e. flameproof “d”, pressurized “p”, or restricted breathing “nR”.

K.4 Optical radiation interlocked with optical breakage “op sh”

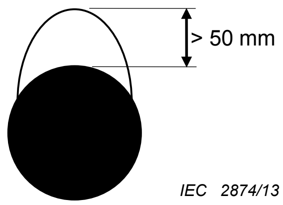
This type of protection is applicable when the radiation is not inherently safe and uses an interlock to cut-off the transmission if the confinement fails. The cut off occurs on a time scale suitably shorter than the ignition delay time.

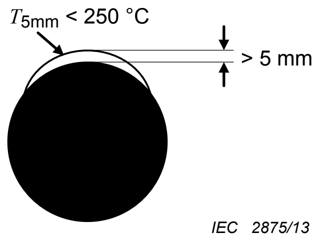
The above concept shall comply with IEC 60079-28.

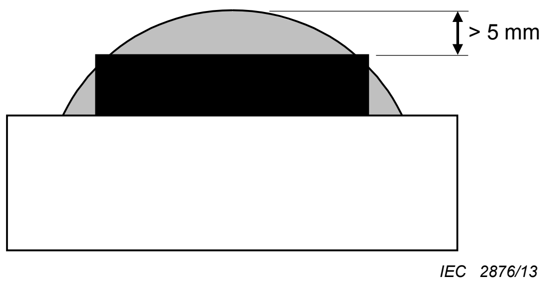
Annex L
(informative)

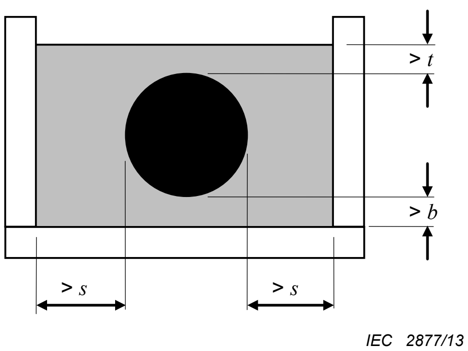
Examples of dust layers of excessive thickness

Annex L provides four examples of excessively thick dust layers (see Figure L.1).

<table>
<tr><td>


</td><td>Figure L.1a – Excessive layer on top of equipment</td></tr>
<tr><td>


</td><td>Figure L.1b – Excessive layer on top of equipment due to low ignition temperature of the dust</td></tr>
<tr><td>


</td><td>Figure L.1c – Excessive layer at the sides of equipment</td></tr>
<tr><td>


</td><td>Figure L.1d – Completely submerged equipment

Dimensions b, s and t to be limited by laboratory investigation</td></tr>
</table>

Figure L.1 – Examples for dust layers of excessive thickness with the requirement of laboratory investigation

Annex M
(informative)

Hybrid mixtures

M.1 General

A hybrid mixture is a combined mixture of a flammable gas or vapour with a dust or flyings. This hybrid mixture may behave differently than the gas/vapour or dust individually. The number of situations that may be encountered in industry will be highly variable and as such it is not practical to provide specific guidance. However Annex M provides guidance on issues that should be considered when hybrid mixtures are found.

M.2 Concentration limits

A hybrid mixture may form an explosive atmosphere outside the individual explosive limits of the gas/vapour or explosive concentrations for the dust. It is recommended, unless further data is available, that a hybrid mixture is considered explosive if the concentration of the gas/vapour exceeds 25 % of the LEL or the concentration of the dust exceeds 25 % of the MEC.

M.3 Energy/temperature limits

Where a hybrid mixture exists the minimum ignition parameters such as MIE and auto-igniting temperature for gas/vapour or minimum ignition temperature of a dust cloud could be lower than any component parameter in the mixture. In the absence of other information the parameters used should be the lowest of any component in the mixture.

M.4 Selection of equipment

Equipment should be selected that as a minimum requirement meets the criteria for both the gas/vapour and dust components concerned. Care should be taken with assessment of the required temperature class considering that a dust layer may increase the temperature of the equipment above that normally assessed for the gas / vapour condition on its own. This may either be due to an increase in the surface temperature of an enclosure or the internal component temperatures. The gas/vapour temperature class assigned to equipment that has alternative ratings for both gas/vapour and dust hazards is not valid where the enclosure is subject to dust layers.

M.5 Use of flameproof equipment

When using flameproof equipment in a hybrid mixture be aware that the flame transmission is not verified with an external explosive dust atmosphere and the protection technique may also be compromised due to dust in the flame path which may result in the ejection of hot particles.

M.6 Electrostatic hazard

Consideration should be given to equipment that is marked with a warning concerning electrostatic hazards to ensure that the dust conditions do not create electrostatic hazards.

M.7 Installation requirements

Cabling, cable glands, electrical protection and other installation factors should meet the requirements for both the gas/vapour and dust components concerned.

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