

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

Withdawn



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EXPLOSIVE ATMOSPHERES –

Part 14: Electrical installations design, selection and erection

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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 fourth edition cancels and replaces the third edition published in 2002 and constitutes a technical revision with respect to gases and vapours and incorporates the requirements for dusts from IEC 61241-14 (2004). The incorporation of requirements for dust is without technical change.

The significant technical changes with respect to the previous edition are as follows:

- Knowledge, skills and competencies of "Responsible Persons", "Operatives" and "Designers" are explained in Annex F.
- Equipment Protection Levels (EPLs) have been introduced and are explained in the new Annex I.
- Dust requirements included from IEC 61241-14, Ed. 1.0.

NOTE Dust requirements are included as an interim presentation for the purpose of this edition and will be refined in a next edition with other required technical changes.

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

FDIS	Report on voting
31J/150/FDIS	31J/152/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 maintenance result 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- withdrawn,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.

Withdrawal

INTRODUCTION

Preventive measures to reduce the explosion risk from flammable materials are based on three principles, which shall be 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 or IEC 61241-10). 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 to be installed in areas where dangerous concentrations and quantities of flammable gases, vapours, mists 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 apparatus in locations

where such combustible materials are present, and suitable precautions must therefore be taken to ensure that all such apparatus is adequately protected so as to reduce the likelihood of ignition of the external explosive atmosphere. In electrical apparatus, potential ignition sources include electrical arcs and sparks, hot surfaces and frictional sparks.

Areas where dust, flyings and fibres in air occur in dangerous quantities are classified as hazardous and are divided into three zones according to the level of risk.

Combustible dust can be ignited by equipment in several ways:

- by surfaces of the apparatus 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 apparatus.

In order to avoid dust ignition hazards it is necessary 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 combustible 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 IEC 60079 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 is based on the assumption that electrical equipment is correctly installed, tested, maintained and used in accordance with its specified characteristics.

Inspection, maintenance and repair aspects play an important role in control of hazardous area installations and the user's attention is drawn to IEC 60079-17 and IEC 60079-19 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.

In IEC 61241-1, for protection by enclosure 'tD', two different types of practice, A and B, are specified and are intended to provide an equivalent level of protection.

Both of these practices are in common use and the requirements of each should be followed without mixing either the apparatus requirements or selection/installation requirements of the two practices. They adopt different methodology with the primary differences being:

Practice A	Practice B
Written principally as performance based requirements	Written as both performance and prescriptive based requirements
Maximum surface temperature is determined with 5 mm layer of dust and installation rules require 75 °C margin between the surface temperature and ignition temperature of the particular dust	Maximum surface temperature is determined with 12,5 mm layer of dust and installation rules require 25 °C margin between the surface temperature and ignition temperature of the particular dust
A method of achieving the required dust ingress protection by the use of resilient seals on joints and rubbing seals on rotating or moving shafts or spindles and determining dust ingress according to IEC 60529 -IP Code	A method of achieving the required dust ingress protection by specified widths and clearances between joint faces and, in the case of shafts and spindles, specified lengths and diametrical clearances between moving and stationary parts and determining dust ingress according to the heat cycling test

Withdrawal

EXPLOSIVE ATMOSPHERES –

Part 14: Electrical installations design, selection and erection

1 Scope

This part of IEC 60079 contains the specific requirements for the design, selection and erection of electrical installations in hazardous areas 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 methods of protection may be necessary. The method used should not adversely affect the integrity of the enclosure.

The requirements of this standard apply only to the use of equipment under normal or near normal atmospheric conditions. For other conditions, additional precautions may be necessary. For example, most flammable materials and many materials which are normally regarded as non-flammable might burn vigorously under conditions of oxygen enrichment. Other precautions might also be necessary in the use of equipment under conditions of extreme temperature and pressure. Such precautions are beyond the scope of this standard.

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

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

It applies to installations at all voltages.

This standard does not apply to

- electrical installations in mines susceptible to firedamp;
NOTE This standard may apply to electrical installations in mines where explosive gas atmospheres other than firedamp may 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 hybrid mixtures of combustible dust and explosive gas, vapour or mist.

This standard does not take into account of any risk due to an emission of flammable or toxic gas from the dust.

2 Normative references

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

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

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60050-826, *International Electrotechnical Vocabulary – Part 826: Electrical installations*

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 60079-2, *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure “p”*

IEC 60079-5, *Explosive atmospheres – Part 5: Equipment protection by powder filling “q”*

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

IEC/TR 60079-13, *Electrical apparatus for explosive gas atmospheres – Part 13: Construction and use of rooms or buildings protected by pressurization*

IEC 60079-14, *Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations in hazardous areas (other than mines)*

IEC 60079-15, *Electrical apparatus for explosive gas atmospheres – Part 15: Construction, test and marking of type of protection “n” electrical apparatus*

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

IEC 60079-18, *Electrical apparatus for explosive gas atmospheres – Part 18: Construction, test and marking of type of protection encapsulation “m” electrical apparatus*

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

IEC 60079-25, *Electrical apparatus for explosive gas atmospheres – Part 25: Intrinsically safe systems*

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

IEC 60079-27, *Electrical apparatus for explosive gas atmospheres – Part 27: Fieldbus intrinsically safe concept (FISCO) and Fieldbus non-incendive concept (FNICO)*

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

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

IEC 60079-29-2, *Explosive atmospheres – Part 29-2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen*

IEC 60079-31, *Explosive atmospheres – Part 31: Equipment dust ignition protection by enclosure "tD"*¹

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 cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable-Procedure for 1KW pre-mixed flame*

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

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

IEC 60529, *Degrees of protection provided by enclosure (IP code)*

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 61241 (all parts), *Electrical apparatus for use in the presence of combustible dust*

IEC 61241-0, *Electrical apparatus for use in the presence of combustible dust – Part 0: General requirements*

IEC 61241-1, *Electrical apparatus for use in the presence of combustible dust – Part 1: Protection by enclosures "tD"*

IEC 61241-2-1, *Electrical apparatus for use in the presence of combustible dust – Part 2: Test methods – Section 1: Methods for determining the minimum ignition temperatures of dust*

IEC 61241-4, *Electrical apparatus for use in the presence of combustible dust – Part 4: Type of protection "pD"*

IEC 61241-10, *Electrical apparatus for use in the presence of combustible dust – Part 10: Classification of areas where combustible dusts are or may be present*

IEC 61241-11, *Electrical apparatus for use in the presence of combustible dust – Part 11: Protection by intrinsic safety 'iD'*

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

IEC 61558-2-6, *Safety of power transformers, power supply units and similar – Part 2-6: Particular requirements for safety isolating transformers for general use*

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

ISO 10807, *Pipework – Corrugated flexible metallic hose assemblies for the protection of electric cables in explosive atmospheres*

¹ To be published

3 Terms and definitions

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

3.2 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 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 an electrical equipment for explosive atmospheres)

classification of electrical equipment related to the explosive atmosphere for which it is to be used

NOTE 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

maximum permissible surface temperature

highest temperature that a surface of electrical apparatus is allowed to reach in practical service to avoid ignition

NOTE The maximum permissible surface temperature will depend upon the type of dust, whether as a cloud or layer, if a layer, its thickness and the application of a safety factor. For details see 5.6.3.

3.2.5

zones

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

3.2.6**zone 0**

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

3.2.7**zone 1**

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

3.2.8**zone 2**

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

3.2.9**zone 20**

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

3.2.10**zone 21**

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

3.2.11**zone 22**

area in which an explosive atmosphere in the form of a cloud of combustible 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 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 – General

3.5.1

intrinsic safety 'i'

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

NOTE Because of the method by which intrinsic safety is achieved, it is necessary to ensure that not only the electrical equipment exposed to the explosive atmosphere but also other electrical equipment with which it is interconnected is suitably constructed.

3.5.2

intrinsically safe apparatus

electrical apparatus in which all the circuits are intrinsically safe

NOTE Intrinsically safe apparatus should conform to IEC 60079-11, level of protection 'ia', 'ib' or 'ic'.

3.5.3

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 Galvanic isolation frequently utilizes either magnetic (transformer or relay) or opto-coupled elements.

3.5.4

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

NOTE The following apparatus is considered to be simple apparatus:

- a) passive components, e.g. switches, junction boxes, resistors and simple semi-conductor devices;
- b) sources of stored energy 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. Any inductance or capacitance present in these sources of energy are considered as in b) above.

3.5.5

intrinsically safe circuit

circuit in which all the equipment is either intrinsically safe apparatus or simple apparatus

NOTE The circuit may also contain associated apparatus.

3.5.6

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

3.5.7

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)

ratio of inductance (L_o) to resistance (R_o) of any external circuit connected to the connection facilities of the electrical equipment 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.

NOTE Pressurization should conform to IEC 60079-2 'px', 'py' or 'pz'.

3.7.2

continuous dilution (flow)

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 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 Type of protection 'n' should conform to IEC 60079-15 'nA', 'nC' or 'nR'.

NOTE 2 Additionally, the requirements of the equipment standard are intended to ensure that a fault capable of causing ignition is not likely to occur.

NOTE 3 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 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

NOTE Encapsulation should conform to IEC 60079-18 'ma', 'mb' or 'mc'.

3.12

dust ignition protection type 'tD'

type of protection whereby all electrical apparatus 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 (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

[IEV 826-12-32]

3.13.2

safety extra-low voltage (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

[IEV 826-12-31]

3.14 Equipment

3.14.1

fixed

equipment fastened to a support, or otherwise secured in a specific location

[IEV 826-07-07]

3.14.2

transportable

equipment not intended to be carried by a person nor intended for fixed installation

3.14.3

portable

equipment intended to be carried by a person

3.14.4

personal

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

4 General

4.1 General requirements

Hazardous areas are classified into zones 0, 1 and 2 for gases vapours and mists according to IEC 60079-10, and into zones 20, 21 and 22 for combustible dusts according to IEC 61241-10 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 with the lowest requirements.

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

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.

All electrical equipment and wiring in hazardous areas shall be selected and installed in accordance with Clauses 5 to 9 inclusive and the additional requirements for the particular type of protection (Clauses 10 to 18).

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, initial inspection of the equipment and installation shall be carried out in accordance with IEC 60079-17.

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 on the occurrence of an explosive atmosphere, 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 to be taken are laid down in writing 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,
- have access to all information necessary to carry out the assessment.

4.2 Documentation

It is necessary to ensure that any installation complies with the appropriate certificates 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.

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

- area classification documents (see IEC 60079-10 and IEC 61241-10) 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 combustible dust);
- optional assessment of consequences of ignition (see 5.3);
- instructions for erection and connection;
- 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 12.2.5);
- manufacturer's/qualified person's declaration;

NOTE The manufacturer's/qualified person's declaration is applicable to situations where uncertified equipment (other than simple apparatus in intrinsically safe or energy-limited circuits) is used.

- 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);
- information necessary for inspection, e.g. list and location of equipment, spares, technical information (see IEC 60079-17);
- details of any relevant calculation, e.g. for purging rates for instruments or analyser houses;
- if repairs are to be carried out by the user or a repairer, information necessary for the repair of the electrical equipment (see IEC 60079-19);
- where applicable, gas or vapour classification in relation to the group or subgroup of the electrical equipment;
- temperature class or ignition temperature of the gas or vapour involved;
- external influences and ambient temperature.

Additional requirements in the case of dust:

- 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
- material characteristics including electrical resistivity, the minimum ignition temperature of the combustible dust cloud, minimum ignition temperature of the combustible dust layer and minimum ignition energy of the combustible dust cloud shall be recorded;
- 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.

NOTE The verification dossier may be kept as hard copy or in electronic form. Methods accepted by legislation in each country may vary the form in which the documentation will be legally accepted.

4.3 Assurance of conformity of equipment

4.3.1 Equipment with certificates according to IEC standards

Equipment with certificate according to IEC 60079 series, IEC 60079-29-1 and IEC 60079-29-2 or IEC 61241 series, meets the requirements for hazardous areas, when selected and installed in accordance with this standard.

4.3.2 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 4.3.1, shall be restricted to circumstances where suitable equipment with certificate 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.

4.3.3 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:

- a) 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) and
- b) any changes to equipment standards relevant to the item considered do not require additional safety precautions.

NOTE 1 The act of introducing equipment where specifications are not identical to an existing installation may cause that installation to be deemed 'new'.

NOTE 2 In the situation where equipment is dual certified (e.g. as intrinsically safe apparatus and independently as flameproof apparatus) 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: apparatus 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 flamepaths before it can be used as flameproof.

4.4 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 F).

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

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

5 Selection of equipment (excluding cables and conduits)

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 combustible dust cloud, minimum ignition temperature of the combustible dust layer and minimum ignition energy of the combustible dust cloud;
- 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 and Annex I).

5.2 Zones

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

NOTE The previous editions of this standard allocated protection concepts to zones, on the statistical basis that the more frequent the occurrence of an explosive atmosphere, the greater the level of safety required against the possibility of an ignition source.

5.3 Relationship between Equipment protection levels (EPLs) and zones

Where only the zones are identified in the area classification documentation, then the relationship between EPL's 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.

NOTE As an alternative to the relationship given in Table 1 between EPLs and zones, EPLs may be determined on the basis of 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 the defined in Table 1.

5.4 Selection of equipment according to EPLs

5.4.1 Relationship between EPLs and types of protection

The recognised types of protection according to IEC standards have been allocated EPLs according to Table 2.

Table 2 – 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		IEC 60079-28
'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' or 'py'	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		IEC 60079-28
'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'	IEC 60079-2
	Fieldbus non-incendive concept (FNICO)		IEC 60079-27
	Protection of equipment and transmission systems using optical radiation		IEC 60079-28
'Da'	Intrinsically safe	'iD'	IEC 60079-11
	Encapsulation	'mD'	IEC 60079-18
	Protection by enclosure	'tD'	IEC 60079-31
'Db'	Intrinsically safe	'iD'	IEC 60079-11
	Encapsulation	'mD'	IEC 60079-18
	Protection by enclosure	'tD'	IEC 60079-31
	Pressurized enclosures	'pD'	IEC 61241-4
'Dc'	Intrinsically safe	'iD'	IEC 60079-11
	Encapsulation	'mD'	IEC 60079-18
	Protection by enclosure	'tD'	IEC 60079-31
	Pressurized enclosures	'pD'	IEC 61241-4

5.4.2 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 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.

5.4.3 Equipment for use in locations requiring EPL 'Gb' or 'Db'

Electrical equipment 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.

5.4.4 Equipment for use in locations requiring EPL 'Gc' or 'Dc'

Electrical equipment 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 $-20\text{ }^{\circ}\text{C}$ to $+40\text{ }^{\circ}\text{C}$. 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.

NOTE 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 $-20\text{ }^{\circ}\text{C}$ to $+80\text{ }^{\circ}\text{C}$. 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 $^{\circ}\text{C}$	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

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 apparatus 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 for both dust clouds and layer thickness of up to 5 mm for type of protection “tD”, practice A and all other types of protection, and 12,5 mm for type of protection “tD” practice B.

For installations where the layer thickness is greater than the values given above, 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 G.

5.6.3.1 Temperature limitations because of the presence of dust clouds

The maximum surface temperature of the apparatus shall not exceed two-thirds of the minimum ignition temperature in degrees Celsius of the dust/air mixture concerned:

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

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

5.6.3.2 Temperature limitation because of presence of dust layers

5.6.3.2.1 Enclosures for practice A and all other apparatus for dust layers

- Up to 5 mm thickness:

The maximum surface temperature of the apparatus when tested in the dust-free test method in 23.4.4.1 of IEC 61241-0 shall not exceed a value of 75 °C below the minimum ignition temperature for the 5 mm layer thickness of the dust concerned:

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

where $T_{5 \text{ mm}}$ is the minimum ignition temperature of 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 practice A apparatus, the maximum permissible surface temperature shall be reduced. For guidance, examples of the reduction in maximum permissible surface temperature of apparatus 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 5.6.3.3

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

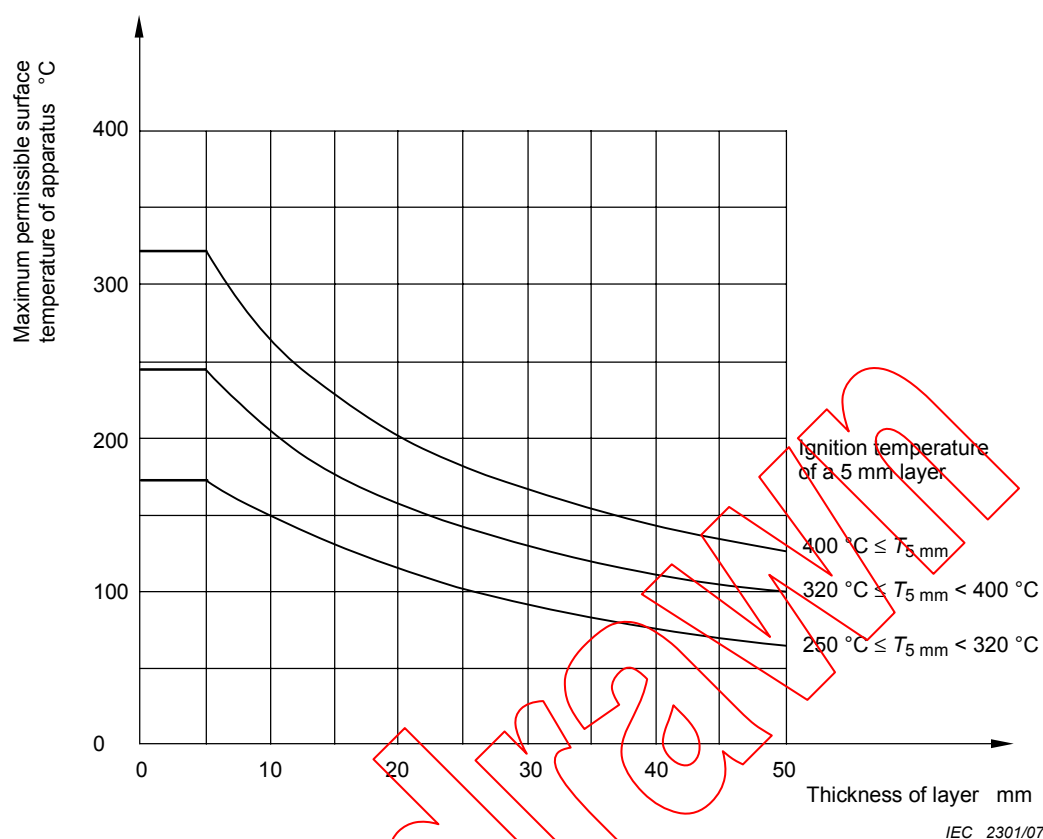


Figure 1 – Correlation between the maximum permissible surface temperature and depth of dust layers

Laboratory verification shall be carried out for apparatus 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 5.6.3.3.

5.6.3.2.2 Enclosures for practice B only apparatus for dust layers up to 12,5 mm thickness

The maximum surface temperature of the apparatus shall not exceed a value of 25 °C below the minimum ignition temperature for the 12,5 mm layer thickness of the dust concerned when the apparatus is tested according to the dust layer test method in 8.2.2.2 of IEC 61241-1:

$$T_{\max} = T_{12,5\text{ mm}} - 25\text{ °C}$$

where $T_{12,5\text{ mm}}$ is the ignition temperature of the 12,5 mm layer of dust.

NOTE $T_{\max}$ obtained from this subclause and $T_{\max}$ from 5.6.3.2.1 are considered to offer equivalent safety.

5.6.3.3 Unavoidable dust layers

Where it cannot be avoided that a dust layer forms around the sides and bottom of an apparatus, or where the apparatus is totally submerged in dust, because of the insulation effect a much lower surface temperature may be necessary. This special requirement can be met by a system of power limitation, with or without inherent temperature control, which shall be determined in accordance with IEC 61241-0.

For installations where the layer depth is greater than 50 mm for enclosures subject to practice A and all other apparatus, or 12,5 mm for enclosures subject to practice B only, the maximum surface temperature of the apparatus may be marked with the maximum

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

5.6.3.4 Maximum permissible surface temperature

The lowest of the values obtained in 5.6.3.2 and 5.6.3.2.1 for practice A and in 5.6.3.2 and 5.6.3.2.2 for practice B, will determine the maximum surface temperature of the apparatus to be used.

If the apparatus is to be used in conditions covered by 5.6.3.3, then these lower values shall be applied.

5.7 Selection of radiating equipment for dust

For equipment radiating in the optical spectral range that is to be installed in the hazardous area, all relevant requirements of this standard, including this clause, shall be applied.

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

5.7.1 Ignition process

Radiation in the optical spectral range, especially in the case of focusing, can become a source of ignition for dust clouds or dust layers.

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 is, in certain circumstances, so greatly absorbed by dust particles, that these particles become an ignition source for dust clouds or for dust layers.

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 on dust 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.

5.7.2 Safety measures in zone 20 or 21

Radiation-generating electrical equipment, if tested and certified in accordance with the requirements for zone 20 or 21, may be used. Independently of this fact, it shall be ensured that irradiation power or irradiation that may penetrate into or occur in zone 20 or 21, even in the case of rare disturbances in the entire part of the radiation process proceeding in zone 20 or 21, and at any point in the radiation cross-section, shall not exceed the following values:

- 5 mW/mm² or 35 mW for continuous wave lasers and other continuous wave sources; and
- 0,1 mJ/mm² for pulse lasers or pulse light sources with pulse intervals of at least 5 s.

Radiation sources with pulse intervals of less than 5 s are regarded as continuous light sources in this respect.

5.7.3 Safety measures in zone 22

Equipment generating radiation may be used. The irradiation intensity or irradiation shall not exceed 10 mW/mm² or 35 mW continuous and 0,5 mJ/mm² for pulse in normal operation.

5.8 Selection of ultrasonic equipment for dust

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

For ultrasonic transmitting equipment that is to be installed in the hazardous area, all relevant requirements of this standard, including those of this subclause, shall be applied.

5.8.1 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.

5.8.2 Safety measures

The following remarks refer solely to the ignition hazard produced by sonic power. In terms of safety, it shall be considered, amongst other things, that electric charges shall have been safely eliminated from the piezo-ceramics (frequently used as transducers in ultrasonic equipment) by means of suitable circuit elements.

5.8.2.1 Safety measures in zone 20 or 21

In zone 20 or 21, ultrasonics may be used only when the working method is recognized as perfectly suitable for use in this zone by reason of the low sonic power available, which shall not exceed a power density in the sound field of 0,1 W/cm² and a frequency of 10 MHz for continuous sources and 2 mJ/cm² for pulse sources. The average power density shall not exceed 0,1 W/cm².

5.8.2.2 Safety measures in zone 22

In zone 22, in the case of working processes using the usual ultrasonic devices (for example, ultrasonic therapy appliances, diagnostic appliances and impulse chip testing devices), no special safety measures against ignition hazards due to the use of ultrasonics themselves are necessary, provided the power density in the sound field generated does not exceed 0,1 W/cm² and an installed frequency of 10 MHz.

5.9 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 (e.g. pressure conditions, chemical, mechanical, vibrational, thermal, electrical, humidity, corrosion). 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 Attention is drawn to the risks that can arise when equipment is subject to prolonged humidity and wide temperature variations. Under such conditions, the equipment should be provided with suitable devices to ensure satisfactory prevention or draining of 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).

NOTE 2 Attention is drawn to the risks that can arise when process fluids become introduced into equipment, (e.g. pressure switches or canned electric motor pumps). Under fault conditions, (e.g. a diaphragm or can failure), the fluid may be released inside the equipment under considerable pressure which 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.

Such equipment 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 3 Where the manufacturer has tested the enclosure to 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 Light metals as construction materials

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.

5.10.1 Gas or vapour

Installation materials (e.g. cable trays, mounting plates, weather protection) shall not contain by mass more than:

- for locations requiring EPL 'Ga'
10 % in total of aluminium, magnesium, titanium and zirconium, or
7,5 % in total of magnesium, titanium and zirconium;
- for locations requiring EPL 'Gb'
7,5 % magnesium and titanium;
- for locations requiring EPL 'Gc'
no requirements

NOTE The above requirements are compatible with those required by IEC 60079-0 for equipment.

5.10.2 Dust

See Annex H.

5.11 Transportable, portable and personal equipment

5.11.1 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 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.

5.11.2 Transportable and portable equipment - Gas

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 D).

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 D).

5.11.3 Personal Equipment - Gas

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 a calculator) shall:

- a) conform to a recognised type of protection appropriate to EPL, gas group and temperature class requirements, or
- b) be subjected to 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 and their use should be assessed as described in this clause.

5.11.4 Dust

Ordinary industrial portable apparatus should not be used in a hazardous area unless the specific location has been assessed to ensure that potentially combustible dust is absent during the period of use ("dust-free" situation). If plugs and sockets are present in a hazardous area, they should be suitable for use in the particular zone and have mechanical and/or electrical inter-locking to prevent an ignition source occurring during insertion or removal of the plug. Alternatively, they should only be energized in a "dust-free" situation.

5.12 Selection of rotating electrical machines

5.12.1 General

Rotating electrical machines are classified in accordance with IEC 60034-1 for duty cycles S1 to S10.

In selecting rotating electrical machines, as a minimum, the following shall be considered:

- duty cycle
- supply voltage and frequency range
- heat transfer from driven equipment (e.g. pump)
- bearing and lubricant life
- insulation class

5.12.2 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 machine. 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 may be 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.

5.13 Luminaires

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

NOTE Low-pressure sodium lamps should not be transported through a hazardous area or installed above a hazardous area owing to the risk of ignition due to free sodium from a broken lamp.

5.14 Plugs and socket outlets for dust

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

In locations requiring EPL “Db” and EPL “Dc” they shall comply with IEC 61241-0 and the following requirements apply.

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

5.14.1 General

Plugs and socket outlets shall be used in combination with a suitable form of flexible connection, as set out in 9.3.3.

5.14.2 Mounting

Socket outlets 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 degree to the vertical, and the opening facing downwards.

5.14.3 Location

Socket outlets shall be installed in locations so that the flexible cord required shall be as short as possible.

6 Protection from dangerous (incendive) sparking

6.1 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 intrinsically safe or energy-limited parts shall be prevented.

6.2 Danger from exposed and extraneous conductive parts

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.

6.2.1 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.

6.2.2 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.

6.2.3 IT type of system earthing

If a type 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, may be necessary (see IEC 60364-4-41).

6.2.4 SELV and PELV systems

Safety extra-low voltage systems (SELV) shall be in accordance with 414 of IEC 60364-4-41. 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. 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.

6.2.5 Electrical separation

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

6.2.6 Above hazardous areas

Equipment that may produce hot particles or hot surfaces located less than 3,5 m above a hazardous area shall be either totally enclosed or provided with suitable guards or screens, to prevent any ignition sources falling into the hazardous area.

NOTE Such items may include:

- fuses that may produce arcs, sparks or hot particles;
- switches 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 lamps.

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

6.3 Potential equalization

6.3.1 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.

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.

NOTE If the armour 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 in 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.

For additional information see 411.3 of IEC 60364-4-41.

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

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

6.3.2 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:

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

6.3.2.1 Gas

For temporary bonding the resistance between metallic parts shall be less than 1 MΩ. Conductors and connections shall be durable, flexible and of sufficient mechanical strength to withstand in-service movement.

NOTE In the absence of IEC standards national or other standards should be followed.

6.3.2.2 Dust

For temporary bonding, the resistance between metallic parts can be greater than that corresponding to a cross-sectional area of 10 mm² of copper.

NOTE Examples of temporary bonding include that made to a portable drum or a vehicle.

6.4 Static electricity

6.4.1 Gas

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

NOTE Detailed information dealing with diameter or width of long parts and limitation of thickness of non-metallic layers can be found in 7.4 of IEC 60079-0.

Cables are exempted from this clause.

The risk of incendive sparking from non-metallic installation materials (e.g. plastic covered cable trays, plastic mounting plates, plastic weather protection) shall be controlled by:

- a) suitable selection of the material so that the insulation resistance of the item does not exceed 1 GΩ; or
- b) 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 exposed (chargeable);
 - 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.

Table 5 – Limitations of areas

EPL requirement of location	Maximum surface area, mm ²		
	Group IIA location	Group IIB location	Group IIC location
'Ga'	5 000	2 500	400
'Gb'	10 000	10 000	2 000
'Gc'	10 000	10 000	2 000

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

6.4.2 Dust

Equipment of plastic material shall be so designed that under normal conditions of use, danger of ignition due to propagating brush discharges is avoided. This can be achieved by not using plastic, which is covering a conductive material. If however the plastic is covering a conductive material the plastic shall have one or more of the following characteristics:

- surface resistance $\leq 10^9 \Omega$ tested according to IEC 60079-0;
- a breakdown voltage ≤ 4 kV (measured across the thickness of the insulating material according to the method described in IEC 60243-1);
- a thickness ≥ 8 mm of the external insulation on metal parts.

NOTE External insulation of 8 mm and greater on metal parts such as measurement probes or similar components make propagating brush discharges unlikely to occur. When evaluating the minimum thickness of the insulation to be used or specified it is necessary to allow for any expected wear under normal usage.

- by limitation of the transferred charge using the test method described in IEC 60079-0;
- by the inability to store a dangerous charge by measurement of capacitance when tested in accordance with the test method in IEC 60079-0.

6.5 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, Annex D).

Subclause 12.3 gives details of lightning protection requirements for Ex 'ia' apparatus installed in locations requiring EPL 'Ga'.

6.6 Electromagnetic radiation

In the design of electrical installations, steps shall be taken to reduce to a safe level the effects of electromagnetic radiation (see IEC 60079-0).

6.7 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.

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

6.8 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 IEC 60079-28. For required safety measures concerning combustible dusts, see 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 may 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 this clause are not applicable to intrinsically safe and energy-limited circuits.

7.1 General

Wiring shall be protected against overload and from the harmful effects of short-circuits and earth faults.

All electrical equipment shall be protected against the harmful effects of short-circuits and earth faults.

Short-circuit and earth-fault protection devices shall be such that auto-reclosing under fault conditions is prevented.

Precautions shall be taken to prevent operation of multi-phase electrical equipment (e.g. three-phase motors) 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 device (or devices) may be used as an alternative to automatic disconnection provided that operation of the warning device (or devices) is immediately apparent so that prompt remedial action will be taken.

7.2 Rotating electrical machines

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.

7.3 Transformers

Transformers shall additionally be protected against overload unless they can withstand continuously the short-circuited secondary current at rated primary voltage and frequency without inadmissible heating or where no overload is to be expected as a result of the connected loads.

7.4 Resistance heating devices

In addition to overcurrent protection, and in order to limit the heating effect due to abnormal earth-fault and earth-leakage currents, the following protection additional shall be installed:

- a) 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 1 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 Ω per volt of rated voltage.

NOTE 2 The above additional protection is not required if the resistance-heating device (for example an anti-condensation heater in an electric motor) is intended to be protected by the manner in which it is installed in the electrical equipment.

Resistance-heating devices shall be protected against excessive surface temperature, where required. Where specified, protective measures shall be applied in accordance with the requirements of the manufacturer and relevant documentation. Where protection is achieved by sensing it shall be either:

- the temperature of the resistance heating device or, if appropriate, of its immediate surroundings; or
- the surrounding temperature and one or more other parameters; or
- two or more parameters other than the temperature.

NOTE 3 Examples of the parameters include: the level, flow, current, power consumption.

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

8 Emergency switch-off and electrical isolation

The requirements of this clause are not applicable to intrinsically safe and energy-limited circuits.

8.1 Emergency switch-off

For emergency purposes, at a suitable point or points outside the hazardous area, there shall be convenient means of switching off electrical supplies to the hazardous area.

Electrical equipment which must continue to operate to prevent additional danger shall not be included in the emergency switch-off and shall be on a separate circuit(s).

NOTE 1 The switching devices installed in the general switchgear are normally adequate with respect to emergency switch-off facilities.

NOTE 2 Emergency switch off should consider isolation of all circuit power supply conductors including the neutral.

NOTE 3 Suitable points for emergency switch off should be assessed relevant to the site distribution, personnel on site and the nature of site operations.

8.2 Electrical isolation

To allow work to be carried out safely, suitable means of isolation (for example isolators, fuses and links) shall be provided for each circuit or group of circuits, to include all circuit conductors including neutral.

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

NOTE There should 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 gas atmosphere continues.

9 Wiring systems

9.1 General

Wiring systems shall comply fully with the relevant requirements of this clause except that intrinsically safe and energy-limited installations need not comply with 9.3.1 to 9.3.6 inclusive.

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 mm².

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.

NOTE 1 Minimum creepage and clearance distances may be determined by the voltage level and/or the requirements of the type of protection.

NOTE 2 Precautions against electrolytic corrosion should be considered.

9.3 Cables

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

9.3.1 Cables for fixed wiring

Cables used for fixed wiring 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, compact, have extruded bedding and fillers, if any, shall be non hygroscopic, or
- b) mineral insulated metal sheathed, or
- c) special, e.g. flat cables with appropriate cable glands.

NOTE Where enclosures are likely to be subjected to large variations in ambient and/or service temperature conditions, a 'pumping' action can transfer the fluids from the hazardous atmosphere through cables which are not substantially compact. Similarly cables with non filled interstices or with hygroscopic fillers (eg. fibre fillers), may transmit flammable fluids through the interstitial spaces of the cable under capillary or hygroscopic action with sufficient partial pressure to exit the cable termination at the extremities of the cable. Particular caution is drawn to the use of electro-pneumatic transducers and the like which employ natural gas as their pneumatic medium. When such cables link between a hazardous and non-hazardous area this may result in a flammable atmosphere being transported to the inside of, for example, control room equipment. The situation is likely to be most acute with equipment installed in a zone 0 or zone 1 location (where the presence of a hazardous atmosphere has a greater likelihood and duration). If these conditions are likely to apply, a cable sealing device (which seals between the inner sheath and the individual conductors) should be used. The application of a cable sealing device may only mitigate the rate of vapour transmission and additional attenuation measures may be necessary.

9.3.2 Cables supplying transportable and portable equipment

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 shall be stranded and shall have a minimum cross-sectional area of 1,0 mm². 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.

9.3.3 Flexible connections for dust

For terminal 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 metallic 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

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

- ordinary tough rubber sheathed;
- ordinary polychloroprene sheathed;
- heavy tough rubber sheathed;
- heavy polychloroprene sheathed;
- plastic insulated and of equally robust construction to heavy tough rubber sheathed flexible cables.

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

9.3.5 Non-sheathed single cores

Non-sheathed single cores 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 communications services to equipment in a hazardous area, it shall be terminated in a non-hazardous area and the service continued into the hazardous area with cable or conduit.

NOTE Uninsulated conductors should not be installed above hazardous areas. 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 12.2.2.5 for intrinsically safe circuits).

Where exposure of this nature is unavoidable, protective measures, such as installation in 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 vibration, they shall be designed to withstand that vibration without damage.

NOTE 1 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 .

NOTE 2 Where cables are secured to equipment or cable trays the bend radius on the cable should be in compliance with the cable manufacturers 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. When high temperature cables are required, this information will be included in the certificate for the equipment or in the manufacturer's recommendations.

9.3.9 Flame propagation

Cables for fixed wiring external to equipment shall have flame propagation characteristics which enable them to withstand the tests according to IEC 60332-1-2, unless they are laid in earth, in sand-filled trenches/ducts or are otherwise protected against flame propagation.

NOTE 1 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 $0,5\text{ mm}^2$ 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 60332-2-2 is recommended.

NOTE 2 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, that 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 IEC 60332-3 series.

9.3.10 Connections of cables to equipment

The connection of cables to the electrical equipment shall maintain the explosion protection integrity of the relevant type of protection.

Where the certificate for the cable gland has an 'X' marking, this cable gland shall be only used for fixed installations. If an 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 and placed within 300 mm of the end of the cable gland.

Where the equipment is portable only glands without 'X' marking shall be used.

Cable glands and/or cables shall be selected to reduce the effects of 'coldflow characteristic' of the cable.

NOTE 1 Cables employ materials which may 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. Low smoke and/or fire resistant cables usually exhibit significant cold flow characteristics. Cold flow could give rise to a reduction in the insulation resistance of the cable and, where reasonably practical, efforts should be made to prevent this by selection of suitable cable glands.

Cable glands with tapered threads shall not be used in enclosures having gland plates with unthreaded entries.

NOTE 2 Tapered threads include NPT threads.

9.4 Conduit systems

National or other standards should be followed for conduit systems.

NOTE IEC standards for conduit systems are currently under consideration.

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 areas 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, conduit shall be provided with a conduit sealing device adjacent to the enclosure.

The conduit shall be wrenchtight 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 wiring enclosures 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).

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

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

9.5 Cable and conduit systems

9.5.1 EPL 'Ga'

Additional requirements for cables in an 'ia' type of protection installation are defined in Clause 12. Additional requirements for cables and conduits used with other types of protection according to IEC 60079-26 shall comply with the relevant protection concepts identified in the documentation.

9.5.2 EPL 'Da'

The requirements for cables for use in intrinsically safe systems are defined in IEC 61241-11.

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

9.5.3 Cable and conduit systems for EPL 'Gb', 'Gc', 'Db' and 'Dc'

Additional requirements for cable and conduit systems are given in clauses 10 to 18 for the appropriate type of protection.

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 Protection of stranded ends

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 requirements of this clause do not apply to intrinsic safety and energy-limited circuits (see 12.2.2.5.3).

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.

9.6.4 Unused openings

Unused openings for cable glands or conduit entries in electrical equipment shall be closed with blanking elements suitable for the relevant type of protection. Blanking elements shall comply with IEC 60079-0, and be of a type that can only be removed with the aid of tools.

NOTE For blanking element used in intrinsic safety circuits, see IEC 60079-11

9.6.5 Fortuitous contact

Except for trace-heating, fortuitous contact between the metallic armouring/sheathing of cables and pipework or equipment containing flammable gases, vapours or liquids shall be

avoided. The insulation provided by a non-metallic outer sheath on a cable will usually be sufficient to avoid this.

9.6.6 Jointing

Cable runs in hazardous areas should, where practicable, be uninterrupted. Where discontinuities cannot be avoided, the joint, in addition to being mechanically, electrically and environmentally suitable for the situation, shall be

- made in an enclosure with a type of protection appropriate to the EPL requirements for the location, or
- providing the joint is not subject to mechanical stress, be 'epoxy' filled, compound-filled or sleeved with heat-shrunk tubing or cold-shrunk tubing, in accordance with the manufacturer's instructions.

Conductor connections, with the exception of those in flameproof conduit systems, intrinsically safe circuits and energy-limited circuits, shall be made only by means of compression connectors, secured screw connectors, welding or brazing. Soldering is permissible if the conductors being connected are held together by suitable mechanical means and then soldered, so there is no stress on the connection.

9.6.7 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.

9.6.8 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.

9.6.9 Static build-up for dust

Cable routing should 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.

9.6.10 Accumulation of combustible 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 combustible 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. Any wiring system subject to dust layers shall comply with the temperature requirements of 5.6.3.4.

10 Additional requirements for type of protection 'd' – Flameproof enclosures

10.1 General

Flameproof enclosures, with only an Ex component enclosure certificate (marked with a 'U'), shall not be installed. They shall always have an equipment certificate for the complete assembly.

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 apparatus group plus a specific gas, and used in that specific gas atmosphere shall be installed in accordance with the requirements for the apparatus group to which the specific gas belongs. For example, equipment marked 'IIB + H₂' and used in a hydrogen atmosphere shall be installed as IIC equipment.

10.2 Solid obstacles

When installing equipment, care shall be exercised to prevent the flameproof flange joint approaching nearer than the distance specified in Table 6 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 6 – 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

10.3 Protection of flameproof joints

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

Flameproof joints shall not be painted.

Painting (by the user) of the enclosure after complete assembly is permitted. The application of grease to the flameproof joint faces will reduce, but not eliminate, the quantity of paint penetrating the gap. Where the manufacturer's documentation does not address joint protection, then only non-setting grease or anti-corrosive agents without evaporating solvents shall be used.

NOTE 1 Silicone based greases are often suitable for this purpose but care needs to be taken concerning use with gas detectors. It cannot be too strongly emphasized that extreme care should be exercised in the selection and application of these substances to ensure the retention of the non-setting characteristics and to allow subsequent separation of the joint surfaces.

NOTE 2 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;
- where the enclosure is used in conjunction with gases allocated to group IIC, the tape should not be applied.

10.4 Cable entry systems

10.4.1 General

It is essential that cable entry systems comply with all the requirements referred to in the equipment standard and documentation. Cable glands shall:

- be appropriate to the type of cable employed;
- maintain the type of protection; and
- be in accordance with 9.3.10

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 part of the bushings are within a terminal compartment which may either be another flameproof enclosure or will be protected by type of protection 'e'. Where the terminal compartment is Ex 'd', then the cable system shall comply with 10.4.2. Where the terminal compartment is Ex 'e', then the cable system shall comply with 11.2.

Where cables enter into flameproof equipment directly, the cable system shall comply with 10.4.2.

NOTE 1 The use of 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.

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 providing 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.

Additional holes shall not be made into flameproof enclosures.

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.

NOTE 2 Gas or vapour migration and 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 migration and preventing the propagation of flame. Examples include compacted strands, sealing of the individual strands, and extruded bedding.

10.4.2 Selection of cable glands

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