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R. STAHL
Am Bahnhof 30
74638 Waldenburg, Germany
T +49 7942 943-0
F +49 7942 943-4333
r-stahl.com

ESSENTIAL EXPLOSION PROTECTION

FOREWORD

In many industries, gases, vapours, mist and dust develop and escape in the course of manufacturing, processing, transporting and storing combustible substances. Explosive atmospheres may arise when they come into contact with oxygen, and if ignited, explosions occur that may result in catastrophic damage to human life and property.

Industries such as oil and gas, chemicals, petrochemicals, pharmaceuticals, fertilisers, food and beverages, biofuel and waste water are considered potential for explosions in general. Safety regulations to avoid explosions have been developed worldwide in the form of legislation, ordinances and standards. These standards ensure compliance to high safety standards.

This publication provides both professionals and others interested in this subject with an insight into the field of explosion protection. It contains the relevant international legal bases and norms, European directives and North American standards. Along with technical principles such as zone classification, temperature classes and protection types, the brochure supplies information on the installation and operation of equipment in hazardous areas. This document serves as the basics and does not replace relevant study of the current applicable regulations.

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1. PHYSICAL PRINCIPLES AND DEFINITIONS

Explosion protection is a key area of safety engineering. So it is essential to understand the fundamental principles of an explosion and its causation factors. The first chapter of our brochure familiarises readers with the main principles and terms in the field of explosion protection.

An explosion is the sudden chemical reaction of a combustible substance with oxygen, resulting in the release of a high amount of energy. An explosion can only occur when three factors are present at the same time (see Fig. 1):

1. Combustible substance.
2. Oxygen (air).
3. Ignition source.

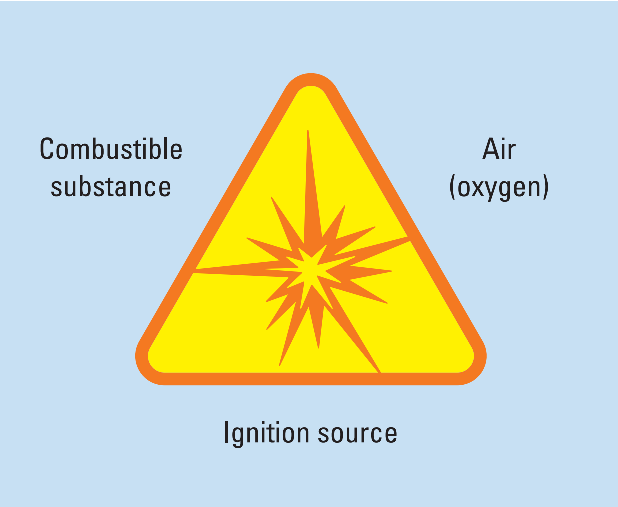


Figure 1: An explosion can only occur when these three factors coincide.

Combustible substance

Combustible substances may be present in the form of gases, mists, vapours or dusts. Safety-relevant parameters need to be considered to characterise hazard potentials.

Explosive atmosphere

Explosive atmospheres contain a mixture of air and combustible gases, vapours, mists or dust in atmospheric conditions in which after ignition the combustion process spreads to the entire unburned mixture. In general, the atmospheric conditions are deemed to be ambient temperatures of -20 °C to +60 °C, a pressure range of 0.8 bar to 1.1 bar and an oxygen content of 21% in the air.

Flashpoint

The flashpoint is the minimum temperature at which a combustible liquid forms an ignitable mixture with air above the surface of the liquid (in normal air pressure conditions). If the flashpoint of a combustible liquid is far higher than the maximum temperatures which arise, an explosive atmosphere cannot be formed. However, the flashpoint of a mixture of various liquids may be lower than that of the individual components. In the German Ordinance on Hazardous Substances (Gefahrenstoffverordnung), besides its boiling point, the flashpoint of a liquid is used to classify liquids (see Table 1).

Table 1: Criteria for combustible liquids

Category	Criteria
1	Flashpoint < 23 °C and boiling point ≤ 35 °C
2	Flashpoint < 23 °C and boiling point > 35 °C
3	Flashpoint ≥ 23 °C and ≤ 60 °C [1]

[1] For the purpose of the CLP Regulation, gas oil, diesel and light heating fuels, which have a flashpoint ranging from 55 °C to 75 °C, may be deemed to belong to Category 3.

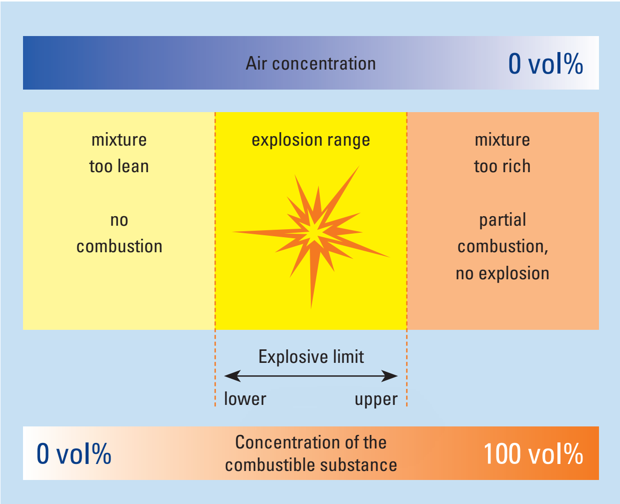


Figure 2: Explosive limits

Table 2: Explosive limits of specified gases and vapours

Designation of substances	Lower explosive limit [vol. %]	Upper explosive limit [vol. %]
Acetylene	2.3	100 (self-decomposing)
Ethylene	2.4	32.6
Petrol	~0.6	~8.0
Benzene	1.2	8.0
Fuel oil / diesel	~0.6	~6.5
Methane	4.4	17.0
Propane	1.7	10.8
Carbon disulphide	0.6	60.0
Hydrogen	4.0	77.0

Extract from the table “Safety characteristics, Vol. 1: Combustible liquids and gases” by E. Brandes and W. Möller, K. Nabert and G. Schön (6th edition).

Explosive limits

To form an explosive atmosphere, the combustible substance must be present in a certain concentration (see Fig. 2). In the case of insufficient concentrations (lean mixture) or excessive concentrations (rich mixture) no explosion takes place, but a stationary or non-combustive reaction. It is only in the range between the lower (LEL) and upper (UEL) explosive limits that the mixture reacts explosively when ignited. The explosive limits depend on the ambient pressure and the percentage of oxygen in the air (see Table 2).

Ignition sources

In order to prevent ignition of a hazardous explosive atmosphere, all potential sources of ignitions must be identified and safeguarded to make them nonthreatening. Ignition of an explosive atmosphere may, for instance, be caused by the following sources:

- Hot surfaces
- Flames and hot gases
- Mechanically generated sparks
- Electrical systems
- Electrical equalising currents, cathodic corrosion protection
- Static electricity
- Lightning
- Electromagnetic waves (high frequency)
- Optical radiation
- Ionising radiation
- Ultrasound
- Adiabatic compression and shock waves
- Exothermal reactions

1. PHYSICAL PRINCIPLES AND DEFINITIONS

Minimum ignition energy
The supply of a specific amount of energy is required to ignite a potentially explosive atmosphere. Minimum ignition energy is the term applied to the minimum amount of energy, for instance when discharging a capacitor, which is just sufficient to ignite the respective combustible mixture. The minimum ignition energy is in the area of 10^{-5} joules for hydrogen and up to a few joules for certain dusts.

Integrated explosion protection
The principle of integrated explosion protection requires that all explosion protection measures be performed in a fixed order, with a distinction between primary, secondary and tertiary (constructional) protection measures.

Primary explosion protection
Primary explosion protection covers all measures that prevent the occurrence of a hazardous explosive atmosphere – for prevention is always better than protection. These precautions should therefore always be implemented first. The following protection measures can be adopted:

- avoidance of combustible substances (alternative technologies).
- inerting (addition of nitrogen, carbon dioxide, etc.).
- limiting of the concentration by means of natural or artificial ventilation.

Secondary explosion protection
If explosion hazards cannot be entirely or only partially excluded by measures to prevent the formation of explosive atmospheres, measures must be adopted to prevent the ignition of explosive atmospheres. The required safety level of these measures depends on the hazard potential at the operating location.

Tertiary or constructional explosion protection
If the occurrence of a hazardous explosive atmosphere cannot be safely prevented and its ignition cannot be excluded, measures must be adopted that limit the impact of an explosion to a negligible extent. The following precautions are possible:

- flameproof or pressure-surge-resistant design.
- pressure relief and pressure compensation equipment.
- explosion suppression with extinguishing devices.

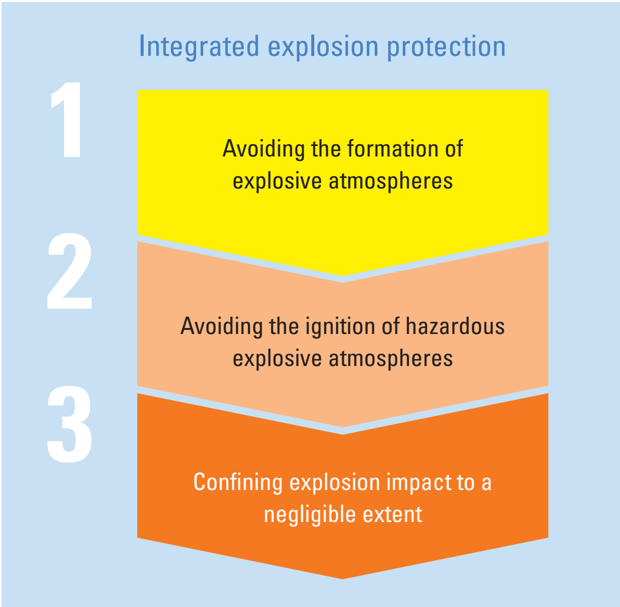


Figure 3: Explosion protection measures

2. LEGAL BASES

The requirements of electrical equipment for explosive atmospheres are multifarious: national and international regulations, directives and standards must be observed and ensure maximum safety. The following chapter summarises the main legal requirements and recommendations worldwide, in the European Union and in North America to provide the reader with an overview.

2. LEGAL BASES

Table 3: Electrical equipment for use in hazardous areas

	IEC	EN
Equipment – General requirements	IEC 60079-0	EN 60079-0
Equipment protection by flameproof enclosures “d”	IEC 60079-1	EN 60079-1
Classification of areas – Explosive gas atmospheres	IEC 60079-10-1	EN 60079-10-1
Classification of areas – Explosive dust atmospheres	IEC 60079-10-2	EN 60079-10-2
Equipment protection by intrinsic safety “i”	IEC 60079-11	EN 60079-11
Equipment protection by pressurized room "p" and artificially ventilated room "v"	IEC 60079-13	EN 60079-13
Electrical installations design, selection and erection	IEC 60079-14	EN 60079-14
Equipment protection by type of protection "n"	IEC 60079-15	EN 60079-15
Artificial ventilation for the protection of analyser(s) houses	IEC/TR 60079-16	
Electrical installations inspection and maintenance	IEC 60079-17	EN 60079-17
Equipment protection by encapsulation “m”	IEC 60079-18	EN 60079-18
Equipment repair, overhaul and reclamation	IEC 60079-19	EN 60079-19
Equipment protection by pressurized enclosure “p”	IEC 60079-2	EN 60079-2
Intrinsically safe electrical systems	IEC 60079-25	EN 60079-25
Equipment with equipment protection level (EPL) Ga	IEC 60079-26	EN 60079-26
Protection of equipment and transmission systems using optical radiation	IEC 60079-28	EN 60079-28
Gas detectors – Performance requirements of detectors for flammable gases	IEC 60079-29-1	EN 60079-29-1
Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen	IEC 60079-29-2	EN 60079-29-2
Gas detectors – Guidance on functional safety of fixed gas detection systems	IEC 60079-29-3	EN 60079-29-3
Gas detectors – Performance requirements of open path detectors for flammable gases	IEC 60079-29-4	EN 60079-29-4
Electrical resistance trace heating – General and testing requirements	IEC 60079-30-1	EN 60079-30-1
Electrical resistance trace heating – Application guide for design, installation and maintenance	IEC 60079-30-2	EN 60079-30-2
Equipment dust ignition protection by enclosure “t”	IEC 60079-31	EN 60079-31
Electrostatics hazards – guidance	IEC/TS 60079-32-1	CLC/TR 60079-32-1
Electrostatics hazards – Tests	IEC 60079-32-2	EN 60079-32-2
Equipment protection by special protection “s”	IEC 60079-33	CLC/TR 60079-33
Intrinsically safe systems with electronically controlled spark duration limitation	IEC/TS 60079-39	CLC IEC/TS 60079-39
Requirements for process sealing between flammable process fluids and electrical systems	IEC TS 60079-40	
Electrical safety devices for the control of potential ignition sources for Ex-Equipment	IEC TS 60079-42	
Equipment in adverse service conditions	IEC TS 60079-43	
Equipment assemblies	IEC TS 60079-46	
Equipment protection by powder filling “q”	IEC 60079-5	EN 60079-5
Equipment protection by liquid immersion “o”	IEC 60079-6	EN 60079-6
Equipment protection by increased safety “e”	IEC 60079-7	EN 60079-7
Material characteristics for gas and vapour classification – test methods and data	ISO/IEC 80079-20-1	EN ISO/IEC 80079-20-1
Material characteristics – Combustible dusts test methods	ISO/IEC 80079-20-2	EN ISO/IEC 80079-20-2
Non-electrical equipment for explosive atmospheres – basic method and requirements	ISO 80079-36	EN ISO 80079-36
Non-electrical equipment for explosive atmospheres – non-electrical protection type of protection constructional safety “c”, control of ignition sources “b”, liquid immersion “k”	ISO 80079-37	EN ISO 80079-37
Safety devices required for the safe functioning of equipment with respect to explosion risks		EN 50495

2.1 EXPLOSION PROTECTION WORLDWIDE

The International Electrotechnical Commission (IEC) is responsible for global standards in the field of electrical engineering. IEC publications regarding the explosion protection of electrical equipment and installations are drafted by the Technical Committee TC31 and are deemed as recommendations. All standards observe the latter as far as possible. Until recent years, regulations for gas explosion hazardous areas were stipulated in the 60079 standard series and those for dust explosion hazardous areas in the 61241 series. As many requirements are identical for both, the two standard series have now been grouped under **IEC 60079**.

The various methods of ensuring **ignition protection for equipment** are called protection types. They are described in the various sections of **IEC 60079** and are construction regulations recognised in many countries (see Table 3).

Systems in hazardous areas must be classified according to their **degree of endangerment** in respect of the likelihood of the occurrence of explosive atmospheres in zones. IEC drafted two standards for this purpose:

- IEC 60079-10-1: Classification of areas – Explosive gas atmospheres.
- IEC 60079-10-2: Classification of areas – Explosive dust atmospheres.

Further standards are available for the **installation and operation** of electrical systems:

- IEC 60079-14: Electrical installations design, selection and erection.
- IEC 60079-17: Electrical installations inspection and maintenance.
- IEC 60079-19: Equipment repair, overhaul and reclamation.

In 2016 standards for **non-electrical equipment** for use in explosive atmosphere were published:

- ISO 80079-36: Non-electrical equipment for explosive atmospheres – basic method and requirements.
- ISO 80079-37: Non-electrical equipment for explosive atmospheres – non-electrical protection type constructional safety “c”, control of ignition sources “b”, liquid immersion “k”.
- ISO/IEC 80079-38: Equipment and components in explosive atmospheres in underground mines

National regulations may however differ from IEC standards. For this reason the extent to which they may be applied in the respective countries must be verified. As this entails a high outlay for development and approval procedures particularly on the part of global players, it seemed advisable to subject approval conditions for electrical equipment to international regulations, thus permitting a free global movement of goods on the basis of country or region-neutral certificates. Furthermore, consistent standards should ensure the maximum safety of Ex products throughout their entire life cycle. IEC therefore introduced a procedure with the aim of standardisation: the **IECEx Scheme**.

2. LEGAL BASES

Recognised IECEx certification bodies (ExCB = certification body) and IECEx test laboratories (ExTLs) exist worldwide and are accredited on the basis of high standard criteria and regularly monitored. An IECEx certificate is only issued if test sample type testing is successful and an audit verifies that an effective quality management system is in place. However, different regional and national approval procedures currently exist all over the world, including for example the ATEX directive in the European Union or national approvals in the USA (UL, FM).

Besides the IECEx Scheme for testing and **certifying new products** (IECEx Equipment Scheme), for some years now the system has also included **certification of service providers** (IECEx Certified Service Facilities Program). The service provider must prove that it maintains a quality assurance system. It is audited every three years by an accredited auditing body (Ex-CB).

The third component of the IECEx Scheme (IECEx Certification of Personnel Competencies) runs on similar lines. It focuses on the **certification of the personal skills** of professionals working in hazardous areas. This is designed as a guarantee for global operators that employees possess the necessary qualification and experience to perform with perfection highly complex tasks in hazardous areas.

In the "Recognised Training Provider (RTP)" programme the IECEx organisation examines the competence of providers offering explosion protection courses. A list of training providers is available on the IECEx website.

2.2 EXPLOSION PROTECTION IN THE EUROPEAN UNION

Explosion protection is governed by directives and standards in the European Union.

Directives

In 1976 the Council of the European Community established the basis for the free movement of explosion-protected electrical equipment within the European Union with its "Directive on the harmonisation of the laws of the member states concerning electrical equipment for use in potentially explosive atmospheres (76/117/EEC)". This directive has since been continuously adapted to state-of-the-art standards by means of single and supplementary directives, which however only concerned electrical equipment.

Full harmonisation and extension to all types of equipment, both electrical and non-electrical, was achieved in 1994 by the new 94/9/EC (ATEX) directive. This was followed in 1999 by the 1999/92/EC directive, which governs operation in hazardous areas and defines safety measures for the persons working in those areas. In February 2014, Directive 2014/34/EU (ATEX) was published. Actual implementation with regards to equipment certification took place on 20 April 2016, replacing Directive 94/9/EC.

Standards

The European EN 50014 – EN 50020 electrical equipment standards were issued in 1978 and replaced the previous national standards for this equipment valid across Europe. Aside from the electrical equipment standards (published by the European Committee for Electrotechnical Standardization CENELEC), the European Committee for Standardization (CEN) has drafted respective standards for non-electrical explosion-protected equipment.

According to an agreement between the European Committee for Electrotechnical Standardization CENELEC and the International Committee for Electrotechnical Standardization IEC, international standards for electrical equipment have generally been adopted by CENELEC as they stand. The EN 50014 ff series defining requirements for equipment in explosive gas atmospheres has been gradually replaced by the EN 60079 series (at international level IEC 60079).

The requirements of protection types for areas with combustible dust were contained in the IEC 61241 series. In Europe these EN 61241 standards replace the former EN 50281 series. However, since most requirements for gas and dust are similar, they are compiled under the series IEC or EN 60079 (see Table 3).

After publication of Directive 94/9/EC in Europe, construction regulations for non-electrical equipment were also specified by the EN 13463 standard series. Some protection principles for electrical equipment were adopted, although amendments were made to address the special requirements of non-electrical equipment. Published in 2016, standards ISO 80079-36 and -37 have been adopted as EN ISO 80079-36 and -37 and supersede the standard series EN 13463.

Other important harmonised standards on explosion protection worthy of mention are EN 1127-1 and -2. They set out methods by which hazards are identified and assessed and outline the respective protection measures. Both preventive explosion protection (avoiding explosive atmospheres and effective ignition sources) and constructive explosion protection (containing explosion effects) are addressed. With the aim of preventing ignition sources as a protective measure, all ignition sources are described and possible measures for their avoidance defined. While Part 2 is relevant for mines, Part 1 deals with other areas (above ground).

- EN 1127-1: Explosive atmospheres –
  Explosion protection – Part 1: Basic principles and methods.
- EN 1127-2: Explosive atmospheres –
  Explosion protection – Part 2: Basic principles and methods in mines.

2. LEGAL BASES

2.2.1 INSTALLATION AND OPERATION

Directive 1999/92/EC "Minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres" explains the principles of the operation of systems in hazardous areas. It is thus directed at operators (employers). They must assess the explosion hazard, classify the system into hazardous zones and document all measures to protect employees in the explosion protection document.

Evaluation of explosion risks

When assessing explosion risks, the following should be taken into account:

- Likelihood and duration of the presence of the explosive atmosphere.
- Likelihood of ignition sources being present, activated, and becoming effective.
- Materials and methods used and their possible interaction.
- The extent of the expected impacts of explosions.

Zone classification

The operator must classify the areas in which explosive atmospheres may be present into zones. It should also ensure compliance with the directive stipulating the minimum requirements (in an organisational and technical respect).

Explosion protection document

The explosion protection document must compulsorily contain details on the following aspects:

- Risk assessment.
- Protection measures adopted.
- Zone classification.
- Observance of minimum requirements. These are divided into organisational measures (e.g. instruction of employees) and technical measures (explosion protection measures).

Directive 1999/92/EC only contains minimum requirements, which may be freely extended on implementation in national legislation.

2. LEGAL BASES

2.2.2 SELECTION OF EQUIPMENT

In 1994 EC Directive 94/9/EC "on the approximation of the laws of the Member States concerning equipment and protective systems for use in potentially explosive atmospheres" was issued to further standardise explosion protection in the EU. It was replaced in 2014 by **EU Directive 2014/34/EU (ATEX)**. It stipulates the requirements for the quality of explosion-protected equipment and protective systems (e.g. by setting out provisions for conformity assessment, protective levels, certification, manufacture and quality assurance, operating manuals and declarations of conformity), in that it prescribes the essential health and safety requirements which must be satisfied by manufacturers and importers. The directive thus ensures the free movement of goods within the European Union and must be adopted as it stands into national legislation. In Germany for instance, this took the form of the Explosion Protection Product Ordinance as 11th Ordinance of the Equipment and Product Safety Act (11. ProdSV). It applies to all industrial hazardous areas (including mining).

The directive applies to **equipment, components** and **protective systems** for use in **hazardous areas**. It also applies to safety, control and regulating apparatus used outside the hazardous area, if the latter is necessary in respect of explosion hazards for the safe operation of equipment in the hazardous area. The directive does not refer to established standards, but sets out fundamental safety requirements, which are deemed as binding quality requirements. Protection from other hazards (e.g. electric shock) which may be caused by this equipment must also be taken into account.

Equipment means machines, apparatus, fixed or mobile devices, control components and instrumentation thereof and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy and/or the processing of material and which are capable of causing an explosion through their own potential sources of ignition.

Component means any item essential to the safe functioning of equipment and protective systems but with no autonomous function.

Protective systems means devices other than components of equipment that are intended to halt incipient explosions immediately and/or to limit the effective range of an explosion. These are generally available in the market for use as autonomous systems.

A **hazardous atmosphere** means an atmosphere which could become explosive due to local and operational conditions.

Equipment categories

Manufacturers whose equipment may represent a potential ignition source and thus may cause an explosion must submit the latter for an ignition hazard assessment. In addition, measures corresponding to the fundamental safety requirements should be envisaged to preclude the risk of ignition by this equipment. The directive classes equipment for hazardous areas (with the exception of mine workings) into three categories with different levels of safety. The required protective measures are adopted to the respective required level of safety (Chapter 3.2).

Conformity assessment and certification

Equipment for use in hazardous areas must first be submitted to the conformity assessment procedure prescribed by the directive before being put into circulation or on the market. Category 1 and M1 equipment must be submitted to a type approval test and certification by a notified inspection authority. The same applies to Category 2 and M2 electric equipment and combustion engines. Manufacturers can determine and document conformity with the directive requirements for other non-electric equipment in this category and for Category 3 equipment. The certificates from a notified inspection authority are recognised throughout the EU. Existing EC type examination certificates continue to retain their validity under the new EU Directive 2014/34/EU.

Marking

EU Directive 2014/34/EU requires special marking:

- CE marking.
- Symbol ⟨Ex⟩ with group, category and additional letter G or D.

(See Chapter 3.6 for more details.)

Operating instructions

The manufacturer’s operating instructions must clearly define the intended use of the equipment by the operator. Minimum requirements of operating instructions include details on safe commissioning, use, mounting and dismantling, upkeep (maintenance and fault clearance) and safe setting-up. It may also be necessary to specify special conditions for safe use (including information on improper use).

Equipment and systems may only be put on the market if they bear the CE mark and the manufacturer’s operating instructions and declaration of conformity are enclosed. The CE mark and written EU declaration of conformity confirm the product’s compliance with all requirements and assessment procedures stipulated in the EU directives.

2. LEGAL BASES

Table 6a: Traditional classification of hazardous areas in North America

Gases, vapours or mist Class I classification	Dust Class II classification	Fibres and lint Class III classification
NEC 500 CEC J18	NEC 500 CEC J18	NEC 500 CEC J18
Division 1 Areas in which dangerous concentrations of incendive gases or vapours • may be present in normal operating conditions • may frequently arise during repair and maintenance work • may arise during operational disruptions or fault conditions and at the same time faults occur on electric equipment which lead to a source of ignition.	Division 1 Areas in which dangerous concentrations of explosive dust atmospheres • may be present in normal operating conditions • may arise during operational disruptions or fault situations and at the same time faults occur on electric equipment which lead to a source of ignition and areas with a dangerous quantity of conductive dust (Group E).	Division 1 Areas in which flammable fibres and lint occur or are processed.
Division 2 Areas in which dangerous concentrations of incendive gases or vapours are kept in closed containers or systems and which can only be released as a result of fault conditions.	Division 2 Areas in which dangerous concentrations of explosive dust atmospheres can only be released in fault conditions.	Division 2 Areas in which flammable fibres are stored or handled differently than in the production process.

2.3 EXPLOSION PROTECTION IN NORTH AMERICA

The basic principles of explosion protection are the same all over the world. Nevertheless techniques and systems have been developed in North America that differ considerably from the IEC system. The differences, for instance, can be noted in the classification of hazardous areas, equipment design and the installation of electrical systems.

2.3.1 INSTALLATION AND OPERATION

In the **USA** the National Electrical Code **(NEC)** and in **Canada** the Canadian Electrical Code **(CEC)** apply to electrical equipment used on hazardous industrial premises. These have the character of installation regulations for electrical facilities in all areas and refer to a number of further standards of other institutions which contain specifications for the construction and installation of suitable equipment.

In North America, hazardous atmospheres are termed “hazardous (classified) locations”. Traditionally, hazardous areas are classified into “Class” and “Divisions” in North America. They comprise areas in which combustible gases, vapours or mists (Class I), dusts (Class II) or fibres or lint (Class III) may be present in dangerous quantities. Based on the likelihood or duration of the presence of these substances, the hazardous locations are traditionally subdivided into Division 1 and Division 2.

Table 6b: Groups

Gas	Dust
A (acetylene)	E (metal)
B (hydrogen)	F (coal)
C (ethylene)	G (grain)
D (propane)	

Table 6c: Temperature classes

Ignition temperature of the gases and vapours in °C	Temperature class	Maximum surface temperature on the equipment in °C
> 450	T1	450
> 300 to 450	T2	300
> 280 to 300	T2A	280
> 260 to 280	T2B	260
> 230 to 260	T2C	230
> 215 to 230	T2D	215
> 200 to 300	T3	200
> 180 to 200	T3A	180
> 165 to 180	T3B	165
> 160 to 165	T3C	160
> 135 to 200	T4	135
> 120 to 135	T4A	120
> 100 to 135	T5	100
> 85 to 100	T6	85

In 1996 the IEC classification system (zone classification) was also introduced for Class I. This amendment was implemented in Article 505 of the NEC, wherein users may choose the optimum system in terms of technology and economic efficiency. In 2005, Zones 20, 21 and 22 for areas with combustible dust (Article 506) were introduced.

The IEC zone concept for Class I was also introduced in Canada (CEC edition 1988), whereby all newly installed systems must be classified according to this concept. In the 2015 edition of the CED the zone concept was also adopted for dust explosion hazardous areas.

2.3.2 SELECTION OF EQUIPMENT

The traditional North American classification system divides Class I flammable gases, vapours, mists and liquids into gas groups (Groups) A, B, C and D and Class II combustible dusts into Groups E, F and G. The letter A denotes the most hazardous gas group, while in IEC and according to the new classification pursuant to Article 505, Group IIC is the most hazardous group.

Determination of the maximum surface temperature to Article 505 in the NEC according to six temperature classes T1 to T6 is in harmony with IEC – with an additional subdivision into temperature classes in the division system. The existing temperature class system was not changed in the CEC 2015 either.

2. LEGAL BASES

The installation method for the zone concept pursuant to NEC 505 complies as far as possible to the traditional class/division systems. Besides the use of fixed pipelines and mineral type MI in Class I, Division 1 or Zone 1, approved cables are also allowed. Special cables may also be used in hazardous areas in Canada.

Furthermore, various standards and regulations govern the construction and testing of explosion-protected electrical systems and equipment in North America. In the USA these are predominately the standards of the International Society for Measurement and Control (ISA), Underwriters Laboratories Inc. (UL) and the Factory Mutual Research Corporation (FM). In Canada the standards of the Canadian Standards Association (CSA) apply.

Enclosure protection types

The counterpart of IEC 60529, which determines the IP protection types (Appendix 5.2) for enclosures, is the Standard Publication No. 250 of NEMA (National Electrical Manufacturing Association) (Appendix 5.3) in the USA. These protection types cannot be exactly equated to those of the IEC as additional environmental influences (such as cooling liquids, cutting oils, corrosion, icing, hail) are addressed. It is to be noted that enclosure types 7, 8, 9 and 10 refer to enclosures for hazardous areas.

Certification

As a rule, electrical apparatus and equipment used on hazardous industrial premises are subject to approval in the USA and Canada. Exceptions include electrical equipment whose design, along with the nature of the explosive atmosphere in which it is used, precludes ignition. The responsible authorities decide whether such equipment is subject to approval. Equipment which has been developed and manufactured for use in hazardous locations must be tested and approved in the USA and Canada by notified inspection authorities.

3. TECHNICAL PRINCIPLES

As Ex areas are not equally hazardous, equipment is subject to different requirements. Chapter 3 provides more information about zone classification, equipment categories, the equipment protection level (EPL), different equipment groups, ignition temperature and temperature classes. You can find out about the various protection types and familiarise yourself with marking principles.

3. TECHNICAL PRINCIPLES

Table 7: Zone classification

Gas	**Zone 0**	an area in which an explosive gas atmosphere is present continuously or for long periods or frequently.
	Zone 1	an area in which an explosive gas atmosphere is likely to occur periodically or occasionally in normal operation.
	Zone 2	an area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, it will exist for a short period only.
Dust	**Zone 20**	an area in which an explosive dust atmosphere, in the form of a cloud of dust in air, is present continuously, or for long periods or frequently.
	Zone 21	an area in which an explosive dust atmosphere, in the form of a cloud of dust in air, is likely to occur in normal operation occasionally.
	Zone 22	an area rea in which an explosive dust 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.

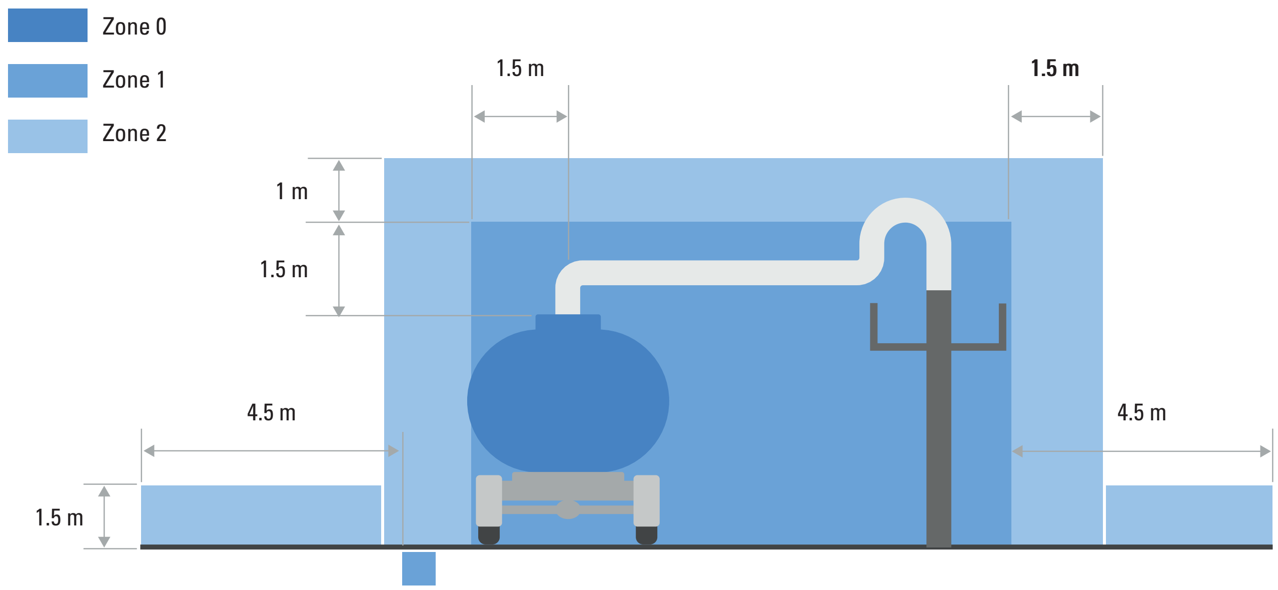


Table 8: Zone classification and equipment assignment according to their category or EPL protection level

	Zone	Duration of the presence of an explosive atmosphere	Equipment category	Equipment protection level (EPL):
Gases, vapours, mist	0	Constant, long-term, persistent	1G	Ga
	1	Occasionally	2G	Gb
	2	Rarely	3G	Gc
Dust	20	Constant, long-term, persistent	1D	Da
	21	Occasionally	2D	Db
	22	Rarely	3D	Dc

3.1 ZONE CLASSIFICATION

Hazardous areas are classified into zones to facilitate the selection of appropriate electrical apparatus as well as the design of suitable electrical installations. Zone classification reflects the likelihood of the occurrence of an explosive atmosphere (see Table 7).

Information and stipulations on zone classification can be found in IEC 60079-10-1 for gas explosion hazardous areas or in IEC 60079-10-2 for areas with combustible dust. There are also industry codes and national standards providing guidance or examples for area classification (see Annex K of IEC 60079-10-1).

The maximum risk potential has to be taken into account when classifying the hazardous areas into zones and determining the necessary protective measures. If there is no expert available in the company to assess the risk of explosion and determine the necessary measures, the advice of a competent authority should be sought.

The equipment used in the defined hazardous zone must meet the requirements of the respectively assigned equipment category or equipment protection level. An overview of the zone classification and assignment of equipment according to their category is illustrated in Table 8.

3. TECHNICAL PRINCIPLES

3.2 EQUIPMENT CATEGORIES AND EQUIPMENT PROTECTION LEVEL (EPL)

Different safety requirements are demanded of the equipment used depending on the likelihood of the occurrence of an explosive atmosphere. The equipment protection level is matched to the hazard potential in the different zones.

In Europe explosion-protected equipment is classified into categories by EU Directive 2014/34 (ATEX). At international level the equipment protection level (EPL) was introduced by IEC 60079 in 2007.

Equipment should be designed with explosion protection measures of varying degrees according to its category or equipment protection level.

Equipment categories

Three categories are envisaged for equipment in hazardous areas – with the exception of firedamp-endangered mining works:

Category 1: Equipment in this category is characterised by a **very high degree** of safety. Even in the rare event of equipment faults they must be safe and thus afford explosion protection so that:

- upon the failure of one device protective measure, at least a second separate protective measure will guarantee the necessary safety.
- upon the occurrence of two different faults the necessary safety is afforded.

Category 2: Equipment and systems offer a **high degree** of safety. The device explosion protection measures in this category are ensured in the case of **frequent** equipment faults or fault conditions (which can be typically expected).

Category 3: Equipment in this category affords the **necessary** degree of safety in **normal** operation.

The additional letter **G** or **D** indicates the use of the equipment in gas explosion hazardous areas (G) or areas with combustible dust (D).

Two categories are envisaged for equipment used in firedamp-endangered mining works:

Category M1: Equipment in this category is characterised by a **very high degree** of safety. Even in the **rare** case of equipment faults they must be able to continue operating in the existing explosive atmosphere and thus display explosion protection measures so that:

- upon the failure of one device protective measure, at least a second separate protective measure will guarantee the necessary safety.
- upon the occurrence of two different faults the necessary safety is afforded.

Category M2: Category M2 equipment and systems offer a **high** degree of safety. Upon the occurrence of an explosive atmosphere it must be possible to switch off the equipment. The device explosion protection measures in this category afford the necessary degree of safety in normal operation – even in adverse operating conditions and in particular when exposed to rough handling and fluctuating environmental influences.

Equipment protection level (EPL):

Pursuant to IEC 60079-0 equipment for hazardous areas is classified into three protection levels.

EPL Ga or Da: Equipment with a **very high** protection level for use in hazardous areas. In normal operation this equipment represents no risk of ignition in the event of predictable or rare faults/malfunctions.

EPL Gb or Db: Equipment with a **high** protection level for use in hazardous areas which represents no risk of ignition in normal operation or in the event of predictable faults/malfunctions.

EPL Gc or Dc: Equipment with an **advanced** protection level for use in hazardous areas. There is no risk of ignition during normal operation. The equipment has additional protective measures that ensure no risk of ignition in the event of typically predictable equipment faults.

The letters **G** and **D** denote whether the equipment and systems are suitable for gas explosion hazardous areas (G) or areas with combustible dust (D).

Two protection levels are defined for firedamp-endangered mining works.

EPL Ma: Equipment with a **very high** protection level that affords the necessary degree of safety. The equipment represents no risk of ignition in normal operation or in the event of predictable or rare faults/malfunctions – even if it is still in operation during a gas leak.

EPL Mb: Equipment with a **high** protection level that affords the necessary degree of safety. The equipment represents no risk of ignition in normal operation in the period between the occurrence of the gas leak and switching off the equipment.

Table 8 illustrates the application range for equipment in a specific category or with a specific protection level in the respective danger zones.

3. TECHNICAL PRINCIPLES

3.3 EQUIPMENT GROUPS

Classification pursuant to European Directive 2014/34/EU (ATEX)

The explosion-protected equipment is classified into two groups.

Equipment group I
Equipment intended for use in underground mining works and surface mining works that may be exposed to the hazard of firedamp and/or combustible dust.

Equipment group II
Equipment intended for use in other areas that may be exposed to an explosive atmosphere.

Electrical equipment for mining works in which in addition to firedamp, gases other than methane may occur, must adhere not only to Group I provisions, but also to the relevant provisions of Group II. Group II equipment is further classified according to application area into equipment for areas exposed to gases, vapours and mist and equipment exposed to dust.

Classification pursuant to IEC 60079

Two groups were formerly defined for explosion-protected equipment.

Group I
Equipment for firedamp-endangered mining works.

Group II
Equipment for hazardous areas –
apart from mining.

Upon publication of IEC 60079-0 in 2007 Group III was introduced for dust explosion hazardous areas. Group II is reserved for equipment in gas explosion hazardous areas.

Group II
Equipment for gas explosion hazardous areas –
apart from mining.

Group III
Equipment for dust explosion hazardous areas –
apart from mining.

Electrical equipment in Group II (gas) is classified according to the characteristics of the explosive atmosphere (for which it is intended) into Groups IIA, IIB and IIC (Table 9). This assignment concerns the flameproof enclosure and intrinsic safety protection types. In the case of flameproof enclosures, it is based on the maximum experimental safe gap (MESG), which is a measure for the discharge behaviour of a hot flame through a narrow gap. The minimum ignition current (MIC) – a variable for the minimum ignition energy of emergent gases and vapours – is definitive for intrinsic safety. Equipment in dust explosion hazardous areas (Group III) is classified according to dust type into Group IIIA (combustible lint), IIIB (non-conductive dust) and IIIC (conductive dust). The latter two groups differ by specific electrical resistance, which for dusts in Group IIIC lies at a value less than or equal to 10^3 Ωm.

Table 9: Equipment group II classification

Group	Typical gas	Maximum experimental safe gap (MESG) in mm	Minimum ignition current ratio*
IIA	Propane	> 0.9	> 0.8
IIB	Ethylene	0.5 … 0.9	0.45 … 0.8
IIC	Hydrogen	< 0.5	< 0.45

* Minimum ignition current ratio in relation to methane

The substances and thus the hazardous areas in which they occur are therefore classified into groups. The equipment deployed must be designed for the requirements of the groups, which range in ascending order from IIA to IIC and IIIA to IIIC. Equipment that complies with IIC criteria may also be used in IIB and IIA areas. Group IIB equipment may also be used in IIA areas. IIA equipment may only be used in IIA areas. This applies likewise for Group IIIA, IIIB and IIIC equipment.

3. TECHNICAL PRINCIPLES

3.4 IGNITION TEMPERATURE AND TEMPERATURE CLASSES

The ignition temperature of an explosive gas atmosphere or dust cloud is the lowest temperature of a heated surface at which a mixture of air and combustible substances in the form of gas, vapour or dust may ignite in the specified conditions.

Combustible gases

Combustible gases and vapours are classified into temperature classes according to their flammability. The maximum surface temperature of electrical equipment must always be lower than the ignition temperature of the gas or vapour and air mixture in which it is used. Of course, equipment classified in a higher temperature class (e.g. T5) may also be used for applications in which a lower temperature class is required (e.g. T2 or T3). North America has a system with further classification into temperature subclasses.

Table 10: Temperature classes

Ignition temperature of gases and vapours in °C	Temperature class	Maximum surface temperature of the equipment in °C
> 450	T1	450
> 300 to 450	T2	300
> 200 to 300	T3	200
> 135 to 200	T4	135
> 100 to 135	T5	100
> 85 to 100	T6	85

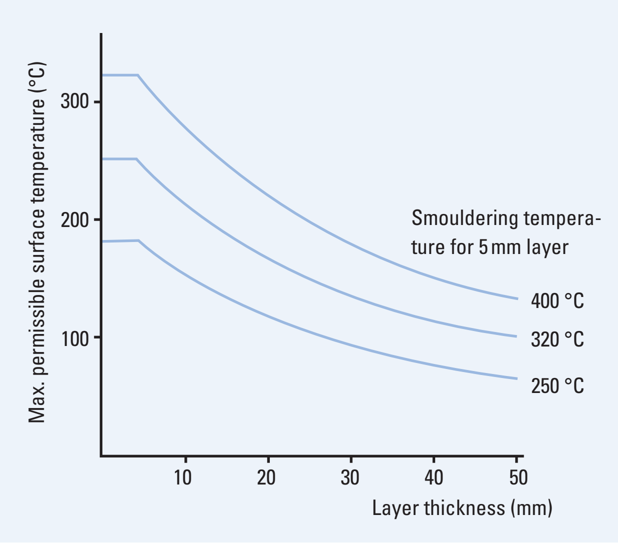


Figure 4: Establishment of the max. surface temperature for dust layers of 5 mm to 50 mm

Combustible dusts

Combustible dusts are not classified into temperature classes. The minimum ignition temperature of the dust cloud is compared with the maximum surface temperature of the equipment, taking a safety factor into account. The maximum equipment surface temperature must not exceed two thirds of the dust cloud ignition temperature. Since dust can also settle on equipment, the ignition temperature of the dust layer (smouldering temperature) must also be considered. The smouldering temperature is the lowest temperature of a hot surface on which a dust layer of 5 mm can ignite.

Adjustment based on the maximum equipment surface temperature is performed with a safety factor of 75 K. As heat insulation increases with thicker layers the maximum permissible equipment surface temperature should be reduced accordingly. This is established according to the diagram (Fig. 4) in IEC 60079-14. If the layer is thicker than 50 mm, the smouldering temperature must be determined by laboratory tests. This also applies to layers thicker than 5 mm when the smouldering temperature is lower than 250 °C. Laboratory tests are also required when equipment is completely covered with combustible dust. Critical equipment surfaces may not be hotter than the lower of the two permissible surface temperatures with reference to the dust cloud and layer.

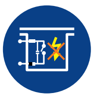
3. TECHNICAL PRINCIPLES

3.5 PROTECTION TYPES

Explosion-protected equipment is predominantly used in locations with a threat of explosion. Explosion-protected electrical equipment for hazardous areas may be designed as per standard series IEC 60079 building provisions in various protection types. Protection types for non-electrical equipment are specified in the ISO 80079 standard series and formerly in EN 13463 in Europe.

The protection type used by a manufacturer for equipment mainly depends on its nature and function. Some protection types are available in different protection levels. They correspond to the equipment categories in Directive 2014/34/EU or the equipment protection level (EPL) in IEC 60079-0. In terms of intrinsic safety, an Ex ia version is available, although it is classified as Category 1 or EPL Ga. It may be installed in Zone 0. The Ex ib version corresponds to Category 2 or EPL Gb. It is suitable for Zone 1. Ex ic can be used as Category 2 or EPL Gc in Zone 2. In safety terms, all standardised protection types in a category or equipment protection level may be deemed equivalent. Tables 11 and 12 provide an overview of the standardised protection types and describe the basic principle and customary use cases. The protection type symbols are simplified (Table 13) by integrating the protection types for dust explosion hazardous areas into the standard series 60079.

Table 11: Protection types for electrical equipment in explosive gas atmospheres, Part 1

Protection type according to IEC, EN, ISA and UL	Representation (Diagram)	Basic principle	Main application
General requirements IEC 60079-0 EN 60079-0 UL 60079-0		This standard specifies the general requirements for explosion-protected electrical equipment and also details equipment marking.	
Increased safety "e" IEC 60079-7 EN 60079-7 UL 60079-7		Additional measures are adopted in this case to afford a higher degree of safety for preventing impermissible high temperatures and the occurrence of sparks and flashovers inside or on outer parts of electrical equipment that do not occur in normal operation.	Terminal and connection boxes, control boxes for installing ex components (with a different protection type), squirrel cage motors, lights eb = use in Zone 1, 2 ec = use in Zone 2
Flameproof enclosure "d" IEC 60079-1 EN 60079-1 UL 60079-1		Parts which can ignite an explosive atmosphere are housed in an enclosure which withstands the pressure of an explosive mixture exploding inside the enclosure and prevents transmission of the explosion to the atmosphere around the enclosure.	Switchgear and control gear, control and display units, control systems, motors, transformers, heaters, lights da = use in Zone 0, 1, 2 db = use in Zone 1, 2 dc = use in Zone 2
Pressurised enclosure "p" IEC 60079-2 EN 60079-2 UL 60079-2		The formation of an explosive atmosphere inside an enclosure is prevented by maintaining a positive internal pressure of inert gas in relation to the surrounding atmosphere and, where necessary, by supplying the inside of the enclosure with a constant flow of inert gas to dilute combustible mixtures.	Switchgear and control cabinets, analysers, large motors pxb = use in Zone 1, 2 and Zone 21, 22 pyb = use in Zone 1, 2 and Zone 21, 22 pyb = use in Zone 2 and Zone 22
Intrinsic safety "i" IEC 60079-11 EN 60079-1 UL 60079-11		Equipment that is used in a hazardous area only contains intrinsically safe electric circuits. An electric circuit is intrinsically safe if no sparks or thermal effects are produced under specified test conditions (which include normal operation and specific fault conditions) which might result in the ignition of a specific explosive atmosphere.	Measurement and control technology, fieldbus technology, sensors, actuators ia = use in Zone 0, 1, 2 and Zone 20, 21, 22 ib = use in Zone 1, 2 and Zone 21, 22 ic = use in Zone 2 and Zone 22 [Ex ib] = associated electrical equipment – installation in safe area
IEC 60079-25 EN 60079-25 UL 60079-25		Intrinsic safety evaluation for defined systems (equipment and cables).	Intrinsically safe systems

3. TECHNICAL PRINCIPLES

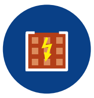
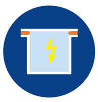
Table 12: Protection types for electrical equipment in explosive areas, Part 2			
Protection type according to IEC, EN, ISA and UL	Representation (Diagram)	Basic principle	Main application
Liquid immersion “o” IEC 60079-6 EN 60079-6 UL 60079-6		Electrical equipment or parts thereof are immersed in a protective fluid (such as oil), so that an explosive atmosphere cannot be ignited above or inside.	Transformers, starting resistors ob = use in Zone 1, 2 oc = use in Zone 2
Powder filling “q” IEC 60079-5 EN 60079-5 UL 60079-5		Filling the enclosure of electrical equipment with a fine granular packing material stops flashovers inside during intended operation igniting the explosive atmosphere around the enclosure. Ignition cannot result either from flames or due to increased temperatures on the enclosure surface.	Sensors, electronic ballast, transmitters q = use in Zone 1, 2
Encapsulation “m“ IEC 60079-18 EN 60079-18 UL 60079-18		Parts that may ignite an explosive atmosphere are embedded in sealing compound to stop ignition of the explosive atmosphere.	ma = use in Zone 0, 1, 2 and Zone 20, 21, 22 mb = use in Zone 1, 2 and Zone 21, 22 mc = use in Zone 2 and Zone 22
Protection type “n” IEC 60079-15 EN 60079-15 UL 60079-15		Electrical equipment cannot ignite a surrounding explosive atmosphere (during normal operation and under defined abnormal operating conditions).	All electrical equipment for Zone 2 nA = non-sparking device nC = devices and components nR = restricted breathing enclosure
Optical radiation “op” IEC 60079-28 EN 60079-28 UL 60079, 28		Appropriate measures prevent ignition of an explosive atmosphere by optical radiation.	Fibre optics / use in gas explosion hazardous areas There are three different methods: Ex op is = inherently safe optical radiation Ex op pr = protected optical radiation Ex op sh = optical radiation with interlock
Protection by enclosure “t” IEC 60079-31 EN 60079-31 UL 60079-31		Thanks to its tightness, dust cannot penetrate the enclosure or reduces it to a negligible degree. Ignitable apparatus can now be mounted in the enclosure. The enclosure temperature must not be sufficient to ignite the surrounding atmosphere.	Switchgear and control gear, control, connection, and terminal boxes, motors, luminaires ta = use in Zone 20, 21, 22 tb = use in Zone 21, 22 tc = use in Zone 22

Table 13: Marking pursuant to standard series IEC 61241 and IEC 60079

Standard series 61241		Standard series 60079		Application range
Standard	Symbol	Standard	Symbol	Zone
Protection via enclosure				
IEC 61241-1	tDA20, tDB20 tDA21, tDB21 tDA22, tDB22	IEC 60079-31	ta	20
			tb	21
			tc	22
Pressurised enclosure				
IEC 61241-4	pD21 pD22	IEC 60079-2	pxb	21
			pyb	21
			pzc	22
Intrinsic safety				
IEC 61241-11	iaD20 ibD21	IEC60079-11	ia	20
			ib	21
			ic	22
Encapsulation				
IEC 61241-18	maD20 maD21	IEC 60079-18	ma	20
			mb	21
			mc	22

3. TECHNICAL PRINCIPLES

Table 14: Protection types for non-electrical equipment in explosive areas

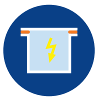
Protective type pursuant to ISO or EN	Representation (Diagram)	Basic principle	Main application
General requirements ISO 80079-36 (formerly EN 13463-1)		This standard specifies the general requirements for explosion-protected electrical equipment and also details equipment marking.	
Constructional safety "c" ISO 80079-37 (formerly EN 13463-5)		Proven technical principles are applied to equipment types which do not have any ignition source in normal operation, so that the risk of mechanical faults causing incendive temperatures and sparks is reduced to a negligible degree.	Couplings, pumps, gear drives, chain drives, conveyor belts
Control of ignition source "b" ISO 80079-37 (formerly EN 13463-6)		Sensors are integrated into the equipment to detect imminent hazardous conditions and adopt countermeasures at an early stage before potential ignition sources become effective. The measures can be initiated automatically by means of a direct connection between the sensors and the ignition protection system or manually by issuing a warning to the operator of the equipment.	Pumps, conveyor belts
Liquid immersion "k" ISO 80079-37 (formerly EN 13463-8)		Ignition sources are rendered ineffective by immersion in a protective liquid or by constant moistening with a liquid film.	Submerged pumps, gears
Flameproof enclosure "d" IEC 60079-1 (formerly EN 13463-3)		Parts that can ignite an explosive atmosphere are housed in an enclosure which withstands the pressure of an explosive mixture exploding inside the enclosure and prevents transmission of the explosion to the atmosphere around the enclosure.	Brakes, couplings
Pressurised enclosure "p" IEC 60079-2 (formerly EN 60079-2)		The formation of an explosive atmosphere inside an enclosure is prevented by maintaining a positive internal pressure of inert gas in relation to the surrounding atmosphere and, where necessary, by supplying the inside of the enclosure with a constant flow of inert gas to dilute combustible mixtures.	Pumps
Protection by enclosure "t" IEC 60079-31		Thanks to its tightness, dust cannot penetrate the enclosure or reduces it to a negligible degree. Ignitable apparatus can now be mounted in the enclosure. The enclosure temperature must not be sufficient to ignite the surrounding atmosphere.	Equipment exclusively for dust explosion hazardous areas

Table 15: Difference between intrinsically safe and associated electrical equipment

Intrinsically safe equipment	Associated electrical equipment	
Ex ib IIC T6 Gb	[Ex ib Gb] IIC	Ex db eb [ib] IIC T6 Gb
All necessary details such as category, explosion group and temperature class are available.	The square brackets indicate that the respective electrical equipment contains an intrinsically safe electric circuit which is listed in Zone 1, explosion groups IIA, IIB and IIC.	
The equipment may be used in Zone 1.	The equipment must be installed outside the hazardous area.	Due to installation in a flameproof enclosure ("db") the equipment may be used in Zone 1.

3.5.1 APPLICATION OF PROTECTION TYPE INTRINSIC SAFETY "i"

The **intrinsic safety** protection type is based on the principle of current and voltage limiting in an electric circuit. The electric circuit energy (which may be capable of causing an explosive atmosphere) is limited to the extent that neither sparks nor impermissible surface heating of electrical components can take place in the surrounding explosive atmosphere. This protection type is particularly common in measurement and control technology in which no high currents, voltage and capacities are required.

Intrinsically safe electrical circuit

An electric circuit in which neither a spark nor the effect of heat can cause a certain explosive atmosphere to ignite.

Intrinsically safe electrical equipment

Electrical equipment in which all circuits are intrinsically safe.

Associated electrical equipment

Electrical equipment that contains both intrinsically safe and non-intrinsically safe electric circuits. It is designed such that the non-intrinsically safe electric circuits cannot compromise the intrinsically safe ones (Table 15).

An essential aspect of the protection type "intrinsic safety" is the matter of reliability in respect of observance of voltage and current limit values, even in the event of specific faults. Intrinsically safe electrical equipment and parts of associated equipment are classified according to this reliability into the different protection levels ia, ib and ic. These protection levels are matched to the various zones. Intrinsic safety ia is thus suitable for use in Zone 0, ib for use in Zone 1 and ic for Zone 2.

A distinction is also drawn between **singe fault safety** and **double fault safety**:

- **Single fault safety:** Upon the failure of one safety-relevant component a second component must assume its task (protection level ib: one redundant component).
- **Double fault safety:** Upon the failure of two safety-relevant components a third component must assume their tasks (protection level ia: two redundant components).

An important safety measure for intrinsically safe circuits is the **safe isolation of all intrinsically safe from all non-intrinsically safe electric circuits**. Excepting safety barriers, safe electric isolation is always required. Galvanic separation is generally recommended for Zone 0. Zener diodes for limiting voltage and other semiconductor components are regarded as fallible and must be safeguarded by redundant components. Sheet or wire-wound resistors for current limiting are regarded as infallible (displaying high resistivity in the event of a fault). A single-component version is sufficient in this case.

3. TECHNICAL PRINCIPLES

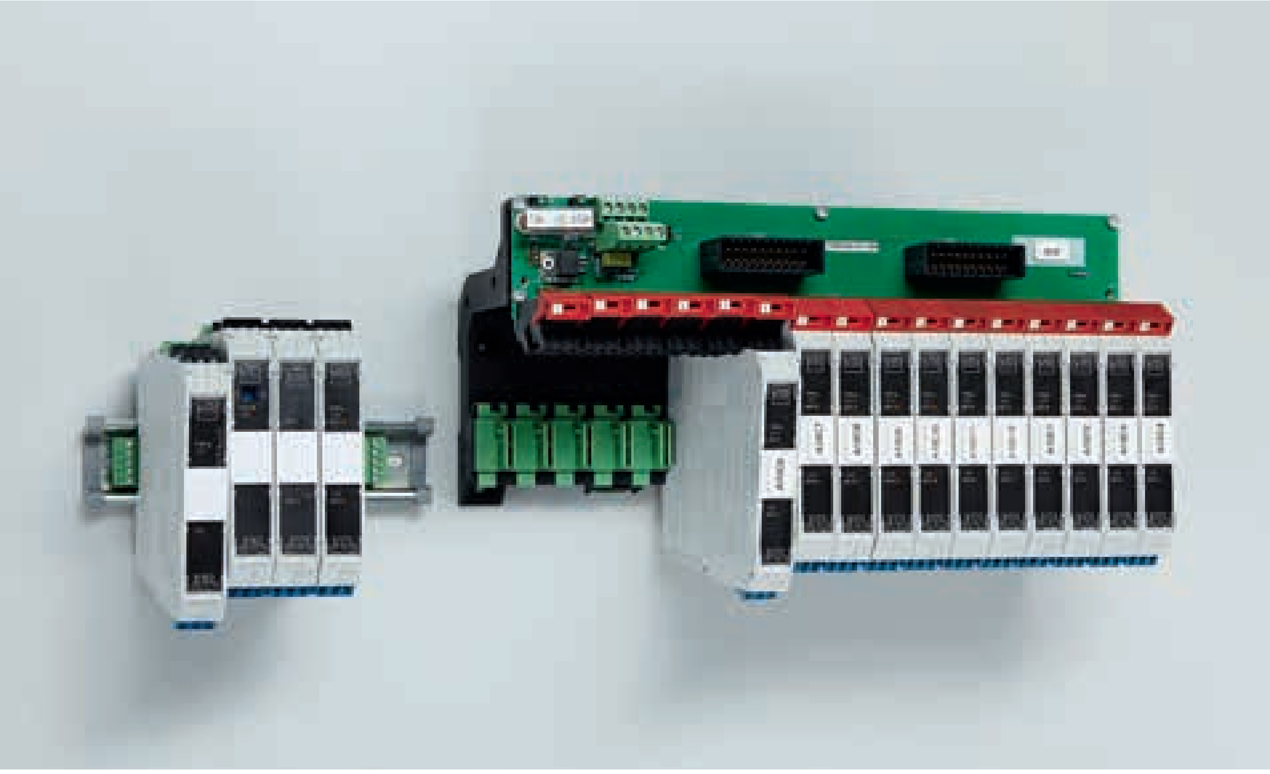


Figure 5: Isolators with IS pac galvanic separation

Interconnecting individual pieces of equipment in an intrinsically safe circuit is permissible subject to the planner observing specific requirements. If associated equipment is interconnected to intrinsically safe equipment, when installing the circuit it should be ensured that the safety characteristic values of the associated and intrinsically safe equipment are matched. (See IEC 60079-14 and IEC 60079-25 for more details on interconnection.) The operator must hold **proof of intrinsic safety** for all intrinsically safe circuits. If available, a system certificate is deemed as proof.

Intrinsically safe fieldbus to FISCO (Fieldbus Intrinsically Safe Concept)

In the case of Manchester-coded bus-fed systems designed in accordance with IEC 61158-2 (“physical layer standard” for fieldbus installations) several field devices are interconnected on a two-wire line and powered via a fieldbus feed unit. This complex interconnection of several devices would result in considerable restrictions in respect of the number of users and line lengths based on a traditional entity concept. The necessary proof of intrinsic safety would be substantial and highly complex. In the mid-1990s PTB therefore developed a simplified concept based on extensive studies and analyses. By applying real parameters more users and more sizeable line lengths are possible, thus greatly simplifying the proving of intrinsic safety. Prerequisite to using this model called **FISCO** is appropriate certification according to FISCO for all members in a FISCO fieldbus system.

FISCO was initially standardised in EN 60079-27, however was transferred into EN 60079-11 in 2008 and EN 60079-25 in 2011. Nowadays end-to-end FISCO fieldbuses are no longer generally installed, as despite simplification only a limited number of users can be connected to a bus. In the more common **high power trunk concept** the number of users is no longer limited by the use of ex i fieldbus couplers (a sort of fieldbus isolator). However activation of the fieldbus devices and simplified proof of intrinsic safety on these Ex i couplers continues to be performed as per FISCO.

3. TECHNICAL PRINCIPLES

Table 16: Standards

	Ex ic	Ex nL	NI
Description	Intrinsic safety	Energy-limited circuits	"Non incendive field wiring"
Standard	IEC 60079-11	IEC 60079-15:2005	FM 3611
Fieldbus	IEC 60079-27-FISCO	IEC 60079-27-FNICO:2005	--
Installation	IEC 60079-14	IEC 60079-14	NEC 500
Maintenance	IEC 60079-17	IEC 60079-17	ANSI/ISA 12.12.01

N.B. Ex nL is not replaced by Ex ic. The transition period expired in 2011.

Table 17: Installation and maintenance

	Ex ic	Ex nL	NI
Application range (gas)	Zone 2	Zone 2	Class I, Div. 2
Application range (dust)	Zone 22	Zone 22	Class II + III, Div. 2
Cables and lines	IEC 60079-14	IEC 60079-14	US standard
Marking	Yes. If coloured, then blue	No special requirements	No special requirements
Distance to normal circuits	50 mm	No (50 mm to Ex i)	Isolation
Proof of energy limiting	Yes	Yes	Yes
Distance to uncoated conductive parts	to non-ex i 50 mm; to other ex i 6 mm; to earth: 3 mm	No special requirements	Isolation
Maintenance*	Yes	Yes	Yes
Upkeep*	Yes	Yes	No

* In NEC 500 a distinction is made between maintenance and upkeep. For instance, during upkeep the live replacement of defective "non-incendive" components is not allowed.

Zone 2 and Division 2: Intrinsic safety ic – energy-limited circuits nL – non-incendive NI

In the USA the principle of energy limiting is addressed variously depending on the application area. Equipment requirements for Class I, Zone 2 correspond most closely to IEC requirements. Intrinsic safety type ic has replaced the energy-limited circuit type nL – as also envisaged in the IEC standards. For Class I, Division 2 energy limiting is implemented in the shape of "non-incendive field wiring (NI)" circuits. The difference between the various methods is illustrated in tables 16 and 17.

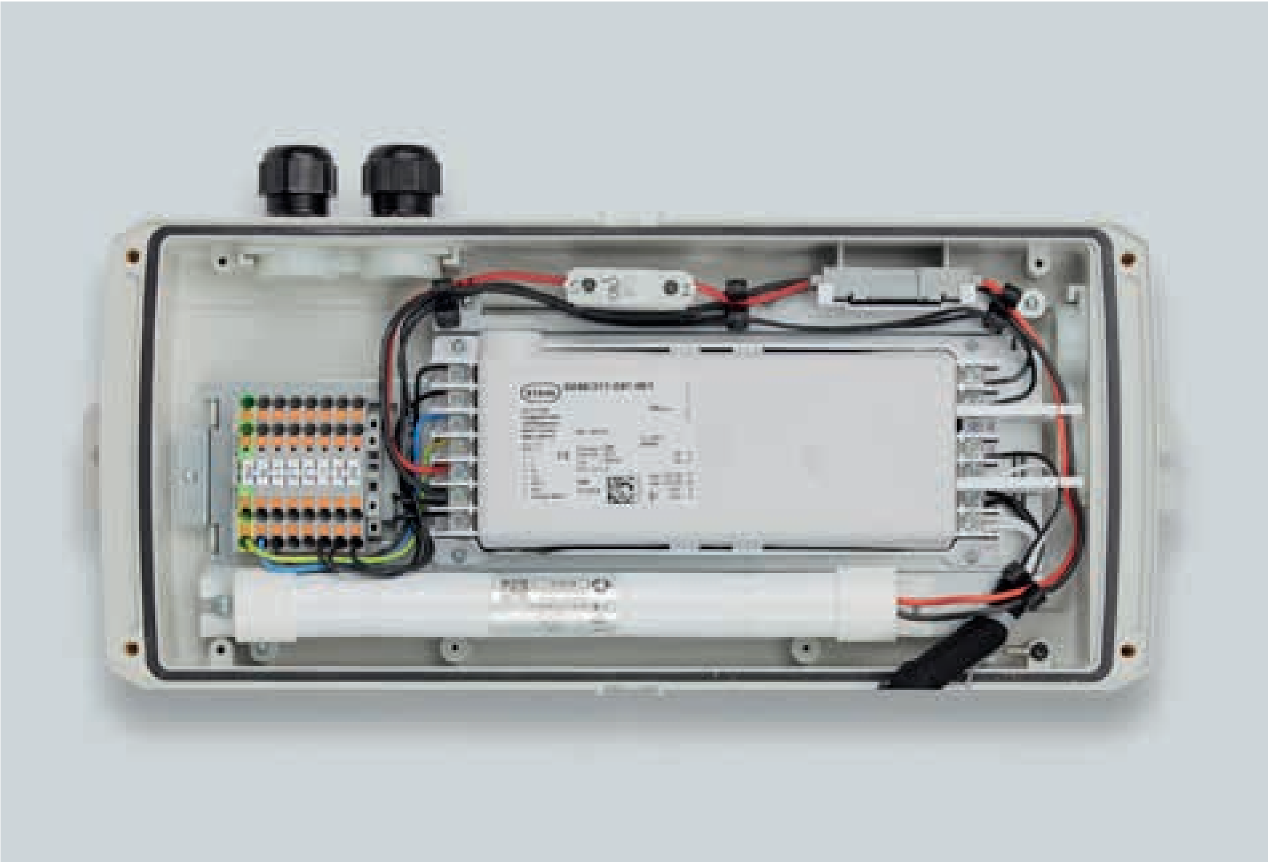


Figure 6: Combination of protection types for an emergency luminaire

3.5.2 APPLICATION AND COMBINATION OF PROTECTION TYPES FLAMEPROOF ENCLOSURE "d" AND INCREASED SAFETY "e"

The most important protection type for switchgears is the **flameproof enclosure** – usually combined with **increased safety**. The protection type increased safety is based on measures that afford a higher degree of safety to avoid the occurrence of ignition sources. However, switchgears produce sources of ignition, and this protection type alone is not sufficient to ensure explosion protection. In conjunction with increased safety, flameproof enclosure as protection type also plays an important role for switchgears. Modern, explosion-protected luminaires also use a combination of several types of protection to achieve the best results with regard to safety, function and economy (Fig. 6).

3. TECHNICAL PRINCIPLES

3.5.3 APPLICATION OF THE PROTECTION TYPE CONSTRUCTIONAL SAFETY "c"

Non-electrical equipment is frequently designed in the **constructional safety** protection type. The risk of faults that may cause ignition sources on equipment is minimised by constructional measures in this type of protection. Constructional measures can be used for instance to avoid hot surfaces or mechanically generated sparks on moving parts. The measures depend mainly on the equipment type and may vary significantly. In this case, potential material pairing, dimensioning, tolerances and lubricants on moving parts play a role. Even maintenance intervals and life cycle monitoring may be of vital importance. The manufacturer defines the designated use in the operating instructions, also specifying the ambient and operating conditions and permissible operating parameters. The operator must adhere to the specifications in the operating instructions.

3.6 MARKING

Worldwide (IEC)

Marking of electrical equipment is defined in IEC 60079-0. In addition to the name of the manufacturer or its trademark, the type designation, serial number and inspection authority with certificate number, a special code is required that describes the use of the equipment:

- The Ex symbol.
- The symbol for each level of protection used. (In the case of associated equipment for installation in dangerous areas, the symbols for the level of protection must be specified in square brackets.)
- Group IIA, IIB or IIC for gas explosion hazardous areas or Group IIIA, IIIB or IIIC for dust explosion hazardous areas.
- Temperature class for gas explosion hazardous areas or maximum surface temperature in °C for dust explosion hazardous areas.
- Explosion protection level (EPL).

Examples:
Ex db eb IIC T4 Gb
Ex ta IIIC T120°C Da

On associated equipment that may be installed in non-explosive areas, the symbols for the level of protection must be specified in square brackets.

Example:
Ex db [ia Ga] IIB T5 Gb

The marking of non-electrical equipment is largely identical to that of electrical equipment. However, instead of various symbols for the level of protection, the letter “h” is always used.

Europe (ATEX)

In Europe, in addition to marking pursuant to the standard (see IEC), the requirements of EU Directive 2014/34/EU (ATEX) must also be satisfied. The following data must be specified:

- Manufacturer’s address.
- CE mark (possibly with code of the named authority).
- The symbol ⟨Ex⟩ and group (e.g.: II) and Category 1, 2 or 3 and letter G (gases) or D (dust).

Example:
⟨Ex⟩ II 2 G

According to the old European Standards EN 50014 ff. "EEx" was used instead of "Ex".

Standards for non-electrical equipment were originally issued by CEN in Europe under standard series EN 13463. Marking is similar to that of electrical equipment – with the following exceptions:

- “Ex” is not specified, as the ⟨Ex⟩ already refers to explosion protection through ATEX.
- The equipment protection level is not specified.

These standards were revised at international level and published in 2016. In Europe they were adopted as standard series EN ISO 80079, so marking is now more similar to that of electrical equipment. Exception: “h” is always specified as the symbol for the protection type.

The marking for electrical and non-electrical equipment is summarised in the appendix on p. 52 onwards.

3. TECHNICAL PRINCIPLES

North America

In addition to usual data (manufacturer, type, serial no., electrical data), explosion protection data should also be included in the equipment marking. Specifications are provided in NEC, CEC and the relevant construction regulations of the inspection authorities.

Electrical equipment approved for Class I, Class II and Class III, Division 1 and Division 2 acc. to NEC 500 - 504 (USA) or for Canada acc. to CEC Appendix J18 should be marked so that the following details are included:

- Class(es), Division(s) (optional for Division 1).
- Gas/dust group(s).
- Service temperature or temperature class (optional for T5 and T6).

Example:
Class I Division 1 Groups C D T4

Equipment specified in the USA for zones pursuant to NEC article 505 or 506, or CEC Section 18, should bear the following marking:

- Class (dispensed with in the USA for dust atmospheres and entirely in Canada).
- Zone (dispensed with in Canada).
- Symbol AEx (USA) or Ex (Canada).
- Abbreviation of the protection type(s) used.
- Group of electrical equipment II or gas group(s) IIA, IIB or IIC.
- Temperature class or max. surface temperature of equipment for dust atmospheres.
- Equipment protection level (EPL).

Example:
Class I, Zone 0, AEx ia IIC T6

Division equipment may be used in zones and vice-versa. However the rules set out in NEC and CEC must be observed.

4. INSTALLATION AND OPERATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

The final chapter provides basic information on the installation and operation of electrical systems in Ex areas. Detailed information on the responsibilities of operators, installers and manufacturers can be found in our “Obligations and Duties” brochure.

4. INSTALLATION AND OPERATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

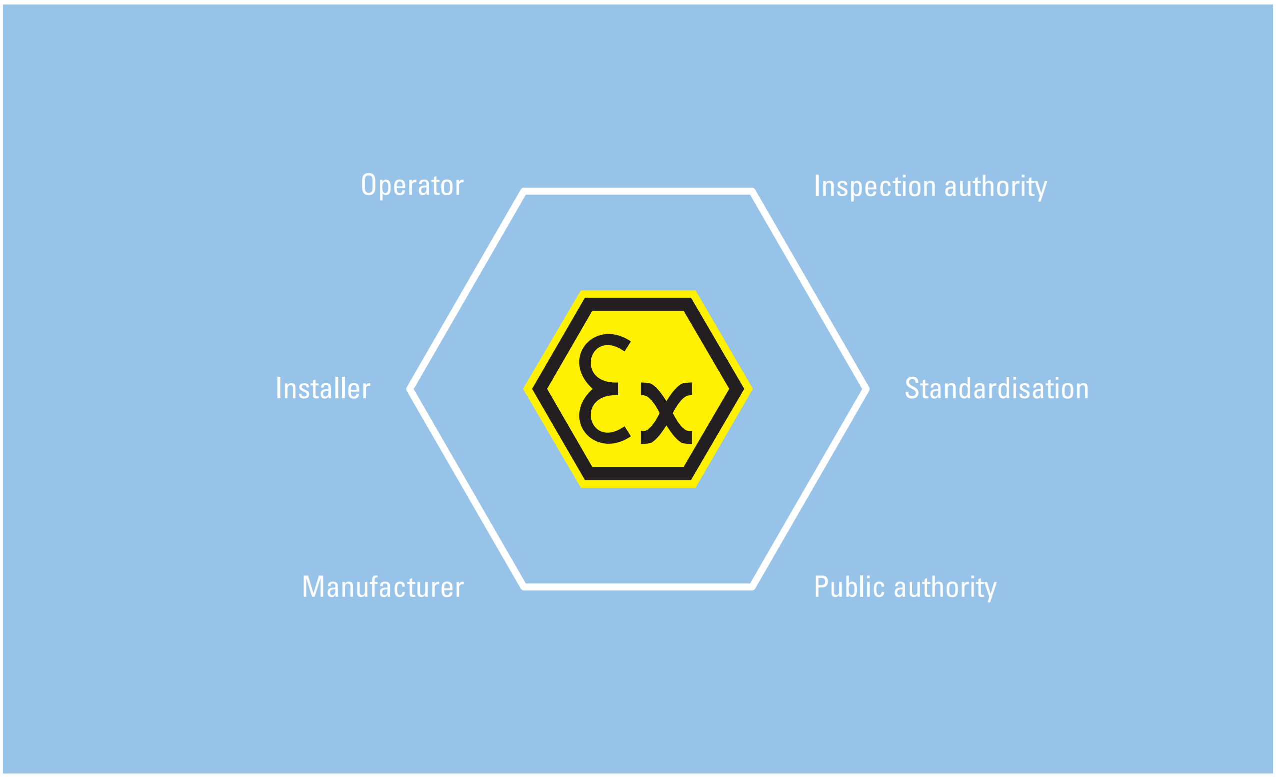


Figure 7: Cooperation of the involved parties

4.1 OPERATOR, INSTALLER AND MANUFACTURER OBLIGATIONS

Safety in hazardous areas can only be ensured by a close and effective working relationship among all parties involved (Fig. 7). Besides operators, installers and manufacturers, this also includes inspection authorities, standardisation authorities and public authorities.

The operator is responsible for the safety of its equipment. It is their duty to judge where there is a risk of explosion and then classify zones accordingly. The operator must ensure that the system is installed correctly and tested before first-time commissioning. The system must be kept in proper working order by regular inspection and maintenance.

Table 18: Explosive atmosphere (gas and combustible dust)

	IEC	EN
Classification of areas - Explosive gas atmospheres	IEC 60079-10-1	EN 60079-10-1
Classification of areas - Explosive dust atmospheres	IEC 60079-10-2	EN 60079-10-2
Electrical installations design, selection and erection	IEC 60079-14	EN 60079-14
Electrical installations inspection and maintenance	IEC 60079-17	EN 60079-17
Equipment repair, overhaul and reclamation	IEC 60079-19	EN 60079-19

The requirements for system operation in hazardous areas are defined in the national regulations. In Europe minimum requirements are stipulated in EC Directive 1999/92/EC. National regulations supply the specific requirements in the respective countries.

Various standards have been issued at international and European level (Table 18).

The installer must observe the installation requirements and select and install the electrical equipment correctly according to its intended use.

Manufacturers of explosion-protected equipment must ensure special quality assurance measures during production and that every piece of manufactured equipment complies with the approved construction type.

4. INSTALLATION AND OPERATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

4.2 AREA CLASSIFICATION AND SELECTION OF EQUIPMENT

Potential explosion hazards are addressed at an early stage in the planning of new systems. When classifying hazardous areas both the strength of potential sources of ignition for combustible substances and the influence of natural or artificial ventilation must be taken into account. The explosion safety characteristics of the combustible substances used must be determined (Appendix 5.1). Only then can a decision be reached on the classification of explosive areas into zones and the selection of suitable equipment.

Equipment may only be used in the ambient temperature range specified in its marking. If the marking does not contain any information, the standard range of -20 °C to +40 °C applies. Electrical equipment must comply with the subgroup IIA, IIB or IIC. It must be selected and installed so that it is protected from external influences that may compromise explosion protection.

4.3 INSTALLATION TECHNIQUES

In the main, three installation systems are used for electrical systems in hazardous areas:

- Cable system with indirect entry.
- Cable system with direct entry.
- Conduit system.

The technical design of the electrical equipment implemented in the individual types of installation varies accordingly.

In the USA only the conduit system or mineral insulated cables (MI) are permitted for all Class 1, Division 1 applications to NEC 501-4, whereby mineral-insulated cables are mainly used as heating lines and fire-resistant signal and control lines. Type MC-HL or ITC-HL cables may also be used in specific conditions. Certain types of cable and line are also permitted in Division 2.

Cable systems

In Europe cable systems are most common, with high-quality cables and lines laid uncovered. It is only in areas in which mechanical damage is likely that they are laid in conduits, which are open at both ends.

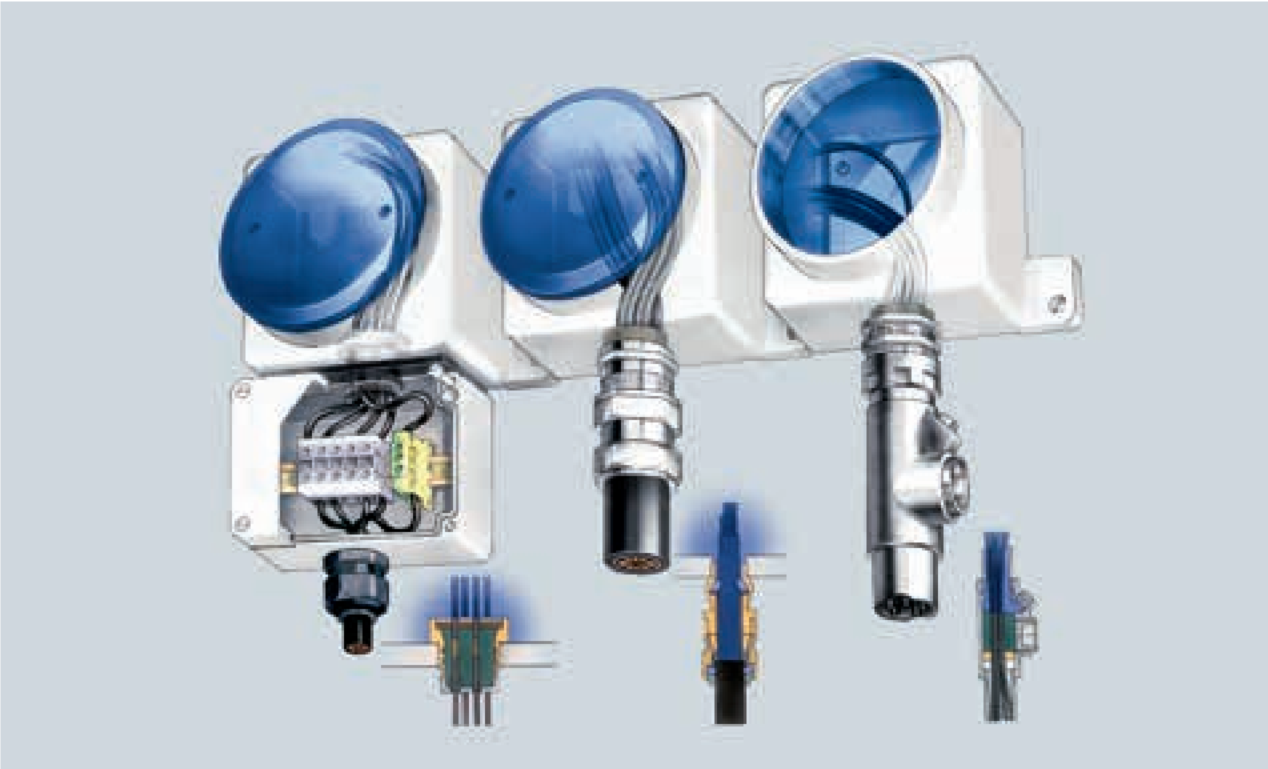


Figure 8: Installation techniques worldwide. Left: cable system with indirect entry. Centre: cable system with direct entry. Right: conduit system.

In the case of **indirect entry** the cables and lines are run via cable entries into an "increased safety" protection type wiring area, where they are connected to terminals also designed for the increased safety protection type. The individual wires are then run via flameproof line bushings into the flameproof enclosure. In contrast to direct entry, the cable bushings are installed by the manufacturer so that the entire flameproof enclosure can be tested at the factory. The installer needs to only open the wiring area, but not the flameproof enclosure, for connection purposes.

In the case of **direct entry** the connecting lines are directly led into the flameproof enclosure. Only cable glands that have been specially designed and approved for this type of entry may be used. The flexible gasket and the cable sheath must form a flameproof joint. Care should therefore be taken to ensure that the right cable gland is selected for the type and structure of the cable and where it is used. In the event of an explosion in the flameproof enclosure the cable must withstand the explosion, so special requirements are placed on the gaskets.

4. INSTALLATION AND OPERATION OF ELECTRICAL EQUIPMENT IN HAZARDOUS AREAS

Until Edition 2007 of IEC 60079-14, a selection matrix was applied to define when additional sealing compound was required in the screw fitting according to gas group, zone and enclosure volume. The matrix was superseded by IEC 60079-14 in 2013. Screw fittings with sealing compound should continue to be used. However, this is not required if a round tight cable* with a minimum length of 3 m is used in conjunction with a screw fitting approved for flameproof enclosures. At this point, the flameproof enclosure depends on the care taken by the installer on laying the cables and lines.

Conduit system

In the case of conduit system installations, the electrical lines are run as single wires into enclosed metal conduits. The conduits are connected to the enclosures by means of screw fittings and sealed at every entry. The entire conduit system is flameproof. The aim of the seal is to prevent explosions which may occur inside the enclosure from penetrating the pipes. Otherwise, extremely high explosive pressures would be created as a result of pre-compression in long cylindrical tubes. For this reason, it is recommended that seals be installed not just at the entries, but also at specific intervals. Drains must be installed at low points where condensate can accumulate.

4.4 INSPECTION AND MAINTENANCE

Regular maintenance is required to maintain the safety of electrical systems in hazardous areas. The personnel performing such maintenance work must be supervised by an explosion protection expert and be informed of the special hazards. Before modification and maintenance jobs, it must be ensured that there is no risk of explosion during this work. Usually, official written permission must be obtained from the management.

A report documenting the work performed should be drafted on completion. In addition it must be confirmed that all relevant regulations were observed.

When replacing components or entire pieces of equipment, the explosion and equipment specifications should be noted.

This publication affords an initial insight into the extensive field of explosion protection. You can find other brochures and information on the subject on our website, r-stahl.com. We also offer a comprehensive range of courses to keep you abreast of changes in explosion protection. From foundation and advanced courses to current developments, you are sure to find the seminar that suits your needs among the many courses on offer. We will be pleased to answer any questions you may have.

* Cables and lines in a thermoplastic, duroplastic or elastomeric material. They must be circular and compact. All embedding or sheaths must be extruded. If filling material is used, it must not be hygroscopic.

5. APPENDIX

5.1 SAFETY CHARACTERISTICS OF FLAMMABLE GASES AND VAPOURS

Table 19: Safety data – Ignition temperature, temperature class and group

Substance designation	Ignition temperature °C	Temperature class	Group
1.2 dichloroethane	440	T 2	II A
Acetaldehyde	155	T 4	II A
Acetone	535	T 1	II A
Acetylene	305	T 2	II C[3]
Ammonia	630	T 1	II A
Petrol fuels	220 to 300	T 3	II A
Benzene (pure)	555	T 1	II A
Cyclohexanone	430	T 2	II A
Diesel fuels	220	T 3	II A
Acetic acid	485	T 1	II A
Acetic anhydride	330	T 2	II A
Ethane	515	T 1	II A
Ethyl acetate	470	T 1	II A
Ethanol	400	T 2	II B
Ethyl chloride	510	T 1	II A
Ethylene	440	T 2	II B
Ethylene oxide	435 (self-decomposing)	T 2	II B
Ethyl ether	175	T 4	II B
Ethyl glycol	235	T 3	II B
Fuel oil EL, L, M, S	220 to 300	T 3	II A
i-Amyl acetate	380	T 2	II A
Carbon monoxide	605	T 1	II A
Methane	595	T 1	II A
Methanol	440	T 2	II A
Methyl chloride	625	T 1	II A
Naphthalene	540	T 1	II A
n-Butane	365	T 2	II A
n-Butanol	325	T 2	II B
n-Hexane	230	T 3	II A
n-Propyl alcohol	385	T 2	II B*
Phenol	595	T 1	II A
Propane	470	T 1	II A
Carbon disulphide	95	T 6	II C[1]
Hydrogen sulphide	270	T 3	II B
Toluene	535	T 1	II A
Hydrogen	560	T 1	II C[2]

*The explosion group for this substance has not yet been determined.
[1] Also explosion group II B + CS2. [2] Also explosion group II B + H2. [3] Also explosion group II B + C2 H2.

5.2 ENCLOSURE PROTECTION TYPES ACCORDING TO IEC 60529 – IPXX

Table 20: Enclosure protection types according to IEC 60529 – IPXX

Ref- erence	First number Touch protection	Foreign body	Second number Water protection
0	No protection	No protection	No protection
1	Protection from contact with back of hand	Protection from solid foreign bodies 50 mm Ø	Protection from water dripping straight down
2	Protection from contact with fingers	Protection from solid foreign bodies 12.5 mm Ø	Protection from water dripping down at an angle
3	Protection from contact with tools	Protection from solid foreign bodies 2.5 mm Ø	Protection from spray water up to 60°
4	Protection from contact with wire	Protection from solid foreign bodies 1.0 mm Ø	Protection from splash water from all directions
5	Protection from contact with wire	Dust-protected	Protection from hose water (IP x5)
6	Protection from contact with wire	Dustproof	Protection from strong hose water (IP x6)
7			Protection against intermittent immersion in water
8			Protection against continuous immersion in water

5.3 ENCLOSURE PROTECTION TYPES ACCORDING TO NEMA STANDARDS

Table 21: Enclosure protection types according to NEMA standards (Publication No. 250 Enclosures for Electrical Equipment 1000 volts maximum)

Reference	Protection type	Installation site
Type 1	Protection against accidental contact with live parts.	Interior
Type 2	Protection against penetration of dripping water and falling dirt.	Interior
Type 3	Protection against swirling dust, rain and hail. No damage from ice formation on enclosure.	Open air
Type 3R	Protection against penetration of hail, swirling dust and rain. External mechanisms stay operational when iced-over.	Open air
Type 4	Protection against falling rain, splashing water and hose water. No damage from ice formation on enclosure.	Interior or open air
Type 4X	Protection against falling rain, splashing water and hose water. No damage from ice formation on enclosure.	Interior or open air
Type 5	Protection from dust and falling dirt and dripping non-corrosive liquids.	Interior
Type 6	Protection from penetration of dust and hose water and water during temporary submersion. No damage from ice formation on enclosure.	Interior or open air
Type 6P	Protection from penetration of dust and hose water and due to prolonged submersion in water. No damage from ice formation on enclosure.	Interior or open air
Type 7	For installation in hazardous areas classified as Class I, Groups A, B, C or D.	Interior
Type 8	For installation in hazardous areas classified as Class I, Groups A, B, C or D.	Interior or open air
Type 9	For installation in hazardous areas classified as Class II, Groups E, F or G.	Interior
Type 10	Enclosure which complies with the Mine Safety Health Administration requirements.	Mining
Type 11	Protection from the corrosive effects of liquids and gases by oil immersion.	Interior
Type 12, 12K	Protection from penetration of dust, dirt and dripping liquids.	Interior
Type 13	Protection from dust, hose water, oil and non-corrosive liquids.	Interior

5.4 MARKING OF ELECTRICAL EQUIPMENT

Type of protection	Symbol alternative	Zone	Main application	Standard
Increased safety “e”	eb ec	1 2	Terminals and terminal boxes, squirrel cage rotors, lights	IEC 60079-7 EN 60079-7
Flameproof enclosure “d”	da db dc	0 1 2	Switchgear and control gear, command and display devices, motors	IEC 60079-1 EN 60079-1
Pressurised enclosure “p”	pxb pyb pzc	1, 21 1, 21 2, 22	Switchgear and control cabinets, large motors	IEC 60079-2 EN 60079-2
Intrinsic safety “i”	ia ib ic	0, 20 1, 21 2, 22	Instrumentation and control technology, fieldbus technology, sensors, actors [Ex ib] = associated electrical equipment in safe area	IEC 60079-11 EN 60079-11
Liquid immersion “o”	ob oc	1 2	Transformers	IEC 60079-6 EN 60079-6
Powder filling “q”	q	1	Sensors, electronic components, electronic ballasts	IEC 60079-5 EN 60079-5
Encapsulation “m”	ma mb mc	0, 20 1, 21 2, 22	Sensors, electronic components	IEC 60079-18 EN 60079-18
Protection type “n”	nA nC nR	2 2 2	Electrical equipment for Zone 2	IEC 60079-15 EN 60079-15
Protection by enclosure “t”	ta tb tc	20 21 22	Switchgear and control gear, control, connection, and terminal boxes, motors, lights	IEC 60079-31 EN 60079-31

Type of protection

Ⓔx II 2G Ex db [ia] IIC T6 Gb

Group

Max. surface temperature

Firedamp-endangered areas		
Group I		Methane
Gas explosion hazardous areas		
Group II	IIA IIB IIC	Propane Ethylene Hydrogen
Dust explosion hazardous areas		
Group III	IIIA IIIB IIIC	Combustible lint Non-conductive dust Conductive dust

Gas explosion hazardous areas: Temperature classes	
Group I	Methane
Gas explosion hazardous areas	
450 °C 300 °C 200 °C 135 °C 100 °C 85 °C	T1 T2 T3 T4 T5 T6
Dust explosion hazardous areas: Surface temperature	
T … °C (Example: T 80°C)	

ATEX marking

Equipment group I: mining; Equipment group II: other areas

Classification	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22	Mining
Hazardous explosive atmosphere	Constantly, frequently or long-term		Occasionally		Seldom and short-term		
Equipment category	1G	1D	2G	2D	3G	3D	M1 or M2

Equipment category and equipment protection level (EPL)

Classification	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22	Mining
EPL (IEC/EN 60079-0)	Ga	Da	Gb	Db	Gc	Dc	Ma or Mb

5.5 MARKING OF NON-ELECTRICAL EQUIPMENT

Type of protection	Symbol Standard	Zone	Main application	Standard
Constructional safety "c"	h	0, 1, 2 20, 21, 22	Couplings, pumps, gear drives, conveyor belts	ISO 80079-37 EN ISO 80079-37
Control of ignition source "b"	h	0, 1, 2 20, 21, 22	Pumps, conveyor belts	ISO 80079-37 EN ISO 80079-37
Liquid immersion "k"	h	0, 1, 2 20, 21, 22	Submerged pumps, gears	ISO 80079-37 EN ISO 80079-37
Flameproof enclosure "d"	h	1, 2	Brakes, couplings	IEC 60079-1 EN 60079-1
Pressurised enclosure "p"	h	1, 2 21, 22	Pumps	IEC 60079-2 EN 60079-2
Protection by enclosure "t"	h	20, 21, 22	Equipment exclusively for dust explosion hazardous areas	IEC 60079-31 EN 60079-31

Type of protection

Ⓔx II 2G Ex h IIC T6 Gb

Group

Firedamp-endangered areas		
Group I		Methane
Gas explosion hazardous areas		
Group II	IIA IIB IIC	Propane Ethylene Hydrogen
Dust explosion hazardous areas		
Group III	IIIA IIIB IIIC	Combustible lint Non-conductive dust Conductive dust

Max. surface temperature

Gas explosion hazardous areas: Temperature classes	
450 °C	T1
300 °C	T2
200 °C	T3
135 °C	T4
100 °C	T5
85 °C	T6
Dust explosion hazardous areas: Surface temperature	
T … °C (Example: T 80°C)	

ATEX marking

Equipment group I: mining; Equipment group II: other areas

Classification	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22	Mining
Hazardous explosive atmosphere	Constantly, frequently or long-term		Occasionally		Seldom and short-term		
Equipment category	1G	1D	2G	2D	3G	3D	M1 or M2

Equipment category and equipment protection level (EPL)

Classification	Zone 0	Zone 20	Zone 1	Zone 21	Zone 2	Zone 22	Mining
EPL (IEC/EN 60079-0)	Ga	Da	Gb	Db	Gc	Dc	Ma or Mb

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IEC 60079 Part 0 to 46
Explosive atmospheres
www.webstore.iec.ch

EN 60529
Degrees of protection provided by enclosures (IP-Code)
www.cenelec.eu

EN 13463 Part 1 to 8
Non-electrical equipment for use in potentially explosive atmospheres
www.cenelec.eu

ISO 80079 Part 36, 37
Explosive atmospheres – Non-electrical equipment for explosive atmospheres
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EN 1127 Part 1 and 2
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