



# Principles of Explosion-Protection

 **COOPER** Crouse-Hinds

**ATEX**



**IECEX**

Edition 2012

# Principles of Explosion-Protection

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# Principles of Explosion-Protection

## Cooper Crouse-Hinds / Cooper Safety: Explosion-protection from one source

### A strong partner for explosion-protection

As a part of Cooper Industries, Cooper Crouse-Hinds is the largest manufacturer worldwide of explosion-protected electrical equipment.

With company offices in Syracuse, New York and production sites and subsidiaries worldwide, Cooper Crouse-Hinds offers explosion-protected control, signal, lighting and energy technology according to NEC and IEC standards from one source.

The products of the brands **CEAG**, **MTL Instruments** and **GECMA** are worldwide leaders in technology, reliability and service. Hence, under the global umbrella of Cooper Crouse-Hinds, you can have access to the solid expertise of highly specialised brands. The unique combination of complementary knowhow and an efficient interlocking of different product areas offers you comprehensive solutions from one source for your complex projects. A global sales network backed up by worldwide distribution offers you the benefits of strong partnerships.

### Specialists for the world market

#### CEAG

Explosion-protected lights, switching devices and energy distribution panels of the **CEAG** brand stand for security, reliability and innovation.

Approved for use in explosive gas and dust-ex environments, our light fittings and electrical apparatus ensure your safety. Innovative design, reliable quality and the robust design guarantees highest operational reliability, even under the most adverse conditions.

#### GECMA

As a manufacturer of a worldwide leading brand for Human Machine Interfaces & Remote PC Terminals for the visualisation and operation on site, **GECMA** offers you internationally approved, high level industrial communication devices, including all important international approvals.

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The name Measurement Technology Limited, or **MTL** is synonymous with technical innovation in the field of intrinsic safety interface modules, overvoltage protection and field bus solutions.

Whether you require conventional cable driven solutions for measuring and control systems or wireless LAN: MTL Instruments offers you innovative solutions for all fields of explosion protected ICA-technique.

#### CAPRI

For more than 50 years the **CAPRI** brand has stood for innovative solutions for electrical terminations in industrial and hazardous environments

**CAPRI** cable glands are designed and manufactured according to the latest standards and are used throughout the world for the safe operation of electrical installations. Metal **CAPRI** glands for use in explosion-protected enclosures fulfil the high requirements of the ATEX directive and of the latest IEC and IECEx standards.

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Founded in 1975, **MEDC** is worldwide leading in the development and production of optical and acoustical signal devices, loudspeakers and manual call points for use in harsh and hazardous onshore and offshore environments.

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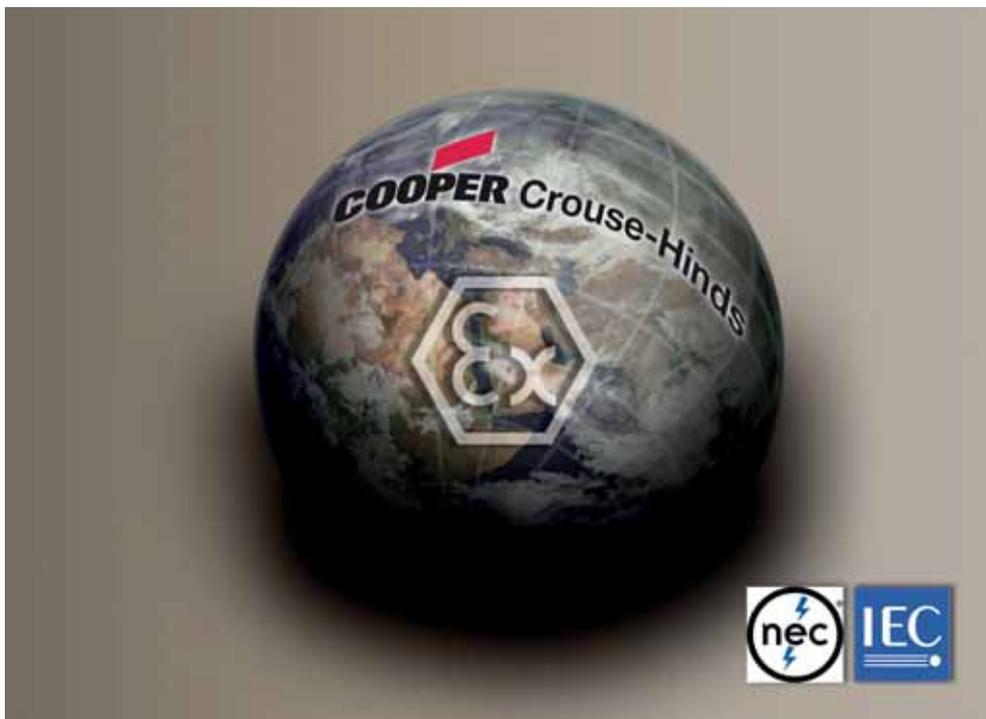
Further information you will find:

 [www.CooperCrouse-Hinds.eu](http://www.CooperCrouse-Hinds.eu)

 [www.MTL-inst.com](http://www.MTL-inst.com)

 [www.GECMA.com](http://www.GECMA.com)

 [www.Cooper-Safety.com](http://www.Cooper-Safety.com)



## Foreword

This publication provides a brief survey of the essential aspects of explosion-protection. The statutory regulations define the obligatory duties of manufacturers, installers and operators of electrical installations in explosive atmospheres. At the end of this publication there is a list of literary references for the interested reader.

# Principles of Explosion-Protection

## The history of explosion-protection and the legislative provisions in Germany and Europe

### The history of explosion-protection and the legislative provisions in Germany and Europe

As early as 1909 Concordia Elektrizitäts-Aktiengesellschaft, later called CEAG, began to manufacture firedamp-protected electrical miners' lamps for the mining industry. Until then, only lamps with a naked flame were available. The first contribution to safety was made in 1815 by the English chemist, Sir Humphry Davy, who developed an oil lamp that prevented the propagation of the flame by means of a close-meshed screen. The elementary experiments carried out by Dr.-Ing. e.h. Carl Beyling, a mining engineer, relating to the specially protected electrical motors and apparatus in coal mines against firedamp were a decisive step in the development of explosion-protection. The governing design principles of firedamp protection devices on electrical machines, transformers and switchgear issued in 1912 were based on the results of these experiments. The following types of protection were accepted as protective measures:

- Flameproof enclosure (then known as closed encapsulation)
- Plate encapsulation
- Oil immersion
- Close meshed screen

From 1924 only incandescent lamps were permitted for lighting hazardous areas, whereby the luminous element was hermetically sealed. The incandescent lamps had to be protected with strong glass bells that also tightly enclosed the lampholder.

Light switches had to be installed outside of the hazardous locations, and in the case of a failure or the lack of explosion-protected lighting, access to these locations was only permitted with safety lamps. Therefore, in general, electrical installations were not used in hazardous locations.

Machines with slip rings or commutators had to be designed in such a way that the slip ring or commutator was, at least, enclosed and the enclosure purged thoroughly under overpressure with extraneous air or a suitable gas. Purging had to start prior to switching on the machine or the machine had to be built into a flameproof enclosure. This requirement applied to all locations where explosive gas or vapour/air mixtures might occur.

The first German regulations on the subject of the protection of hazardous installations were the "Guiding principles on the installation of electrical equipment in hazardous production areas and storage rooms (VDE 0165/1935), which were issued in 1935.

The fundamental revision of these regulations began with the VDE regulations 0171 "Constructional regulations for explosion-protected apparatus", which came into force in 1943. They provided the manufacturers of electrical equipment for use in potentially explosive atmospheres with the necessary documents for a safe design and construction. These regulations not only described the individual types of protection and their scopes of application, but also included a number of constructional specifications and introduced the identification marking **Ex** for electrical apparatus built in compliance with it.

The governing principles and specifications of the VDE regulations 0165 and 0171 were the basis of the police decree dated 13.10.1943 for electrical apparatus in hazardous locations and in mines subject to the hazard of firedamp. The police decree was primarily aimed at the manufacturers of electrical apparatus. It specified that explosion-protected electrical equipment could only be placed on the market, installed and operated if it conformed to the so-called VDE regulations and had successfully passed the specified type and routine tests.



Firedamp-proof miner's lamps (combustion lamps)



Research papers by C. Beyling, mining engineer



Police decree dated 13.10.1943

## The history of explosion-protection and the legislative provisions in Germany and Europe



*ElexV from 1980*

The factory inspectorate division was chosen to be the competent authority to define to what extent a room or plant might be subject to the hazard of explosion.

The “Decree concerning electrical installations in potentially explosive atmospheres (ExVO)”, which was issued in 1963, not only introduced the obligation to have the explosion protected apparatus tested by the Federal Physico-Technical Institute (Physikalisch-Technische Bundesanstalt PTB) or the Mining Test Station (BVS), but also the obligation to obtain the design approval from the authorities of the competent federal state.

In 1975 the Council of the European Community issued framework directives on explosion-protection.

The European standards for electrical equipment for use in hazardous areas were drawn up by CENELEC, the “European committee for electro technical standardization”. In Germany the new European standards EN 50 014 to EN 50 020 were adopted as VDE standards as part of the national standards works.

These new standards DIN EN 50014 to 50020/VDE 0170/0171, Parts 1 to 7, designated as VDE regulations, came into force on 01.05.1978.

The application of these European standards for the construction and testing of explosion-protected electrical apparatus was governed throughout Europe by the “EC Directive 79/196/EC”. With the new regulation, which was now known as ElexV, among other things, on 01.07.1980 this EC Directive was implemented and explosion-protection newly regulated for manufacturers and operators. Furthermore, the expertise of the testing establishments and the design approval were replaced by a type sample test. The type sample test was carried out by authorized testing establishments of the member states of the EU (Notified Bodies). The certificates of conformity and inspection granted on the basis of the said tests were valid throughout Europe.

From 01.07.2003, 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, issued on 23.03.1994 by the European Parliament and Council, irrevocably replaced any previous directives concerning explosion-protection that existed on a European level.

On 12.12.1996, Directive 94/9/EC was converted into national law by the second decree concerning the equipment safety law and the changes relating to the equipment safety law by the explosion-protection decree (ExVO). With this decree, the acetyl decree (AcetV), the decree on flammable liquids (VbF) and the ElexV were also brought into line with the European law.

On 28.01.2000, Directive 1999/92/EC of the European Parliament and Council, dated 16.12.1999, the second important directive concerning explosion-protection, was published in the official gazette of the European communities. It contains minimum requirements for the improvement of the safety and health protection of employees potentially at risk from explosive atmospheres. This EC directive, also called the European Occupational Safety Directive, lays down the rules for operational explosion-protection and is aimed at the operators of installations where explosion hazards are to be expected.

The directive was converted into national law on 03.10.2002 in the “Decree on health and safety protection relating to the provision of work equipment and the use thereof during operation, safety during the operation of installations requiring supervision and the organisation of operational safety provisions (Operational Safety Decree – BetrSichV). The BetrSichV replaces the ElexV for explosion-protection. However, within the scope of the transitional regulations, the ElexV could still be applied for installations that were commissioned before 03.10.2002.



*Explosion-protected plug and socket from the 60's*

# Principles of Explosion-Protection

## Physical principles of explosion-protection

### Explosive atmosphere

Definition:

Is a mixture with air, under atmospheric conditions, with a flammable substance, in the form of gas, vapour, dust, fibres or flyings which, after ignition, permits self-sustaining propagation (IEV 426-01-06).

Atmospheric conditions are defined as: pressures ranging from 80 kPa (0.8 bar) to 110 kPa (1.1 bar), temperatures from -20° to +60°C and air with oxygen content, normally 21% (V/V) (EN 60079-0).

These limitations are necessary, as the essential safety parameters for explosion-protection are a function of the pressure, temperature and oxygen content and can only be considered to be sufficiently constant if they are within the limits stated above.

The European directives and their implementing decrees are based on this specification.

### Hazardous area

Definition:

An 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 electrical apparatus (IEV 426.03.01).

### Upper and lower explosive limits

A mixture is potentially explosive if, under atmospheric conditions, the concentration is within given, substance-specific limits.

### Upper explosive limit (UEL)

Concentration of flammable gas or vapour in air, above which an explosive atmosphere will not be formed (IEV 426-02-10).

### Lower explosive limit (LEL)

Concentration of flammable gas or vapour in air, below which an explosive atmosphere will not be formed (IEV 426-02-09).

Under conditions other than atmospheric conditions, the explosion limits change. For example, as the proportion of oxygen increases, the upper explosive limit is raised.

Generally, the explosive limits are indicated in percent by volume. The percent by volume, abbreviated to %/vol., is the content by volume of the combustible matter in the mixture with air. The lower explosive limit of hydrogen is 4.0 % by volume, and the upper explosive limit 75.6 % by volume. The safety coefficients define quantitative data on the properties of most of the known substances.

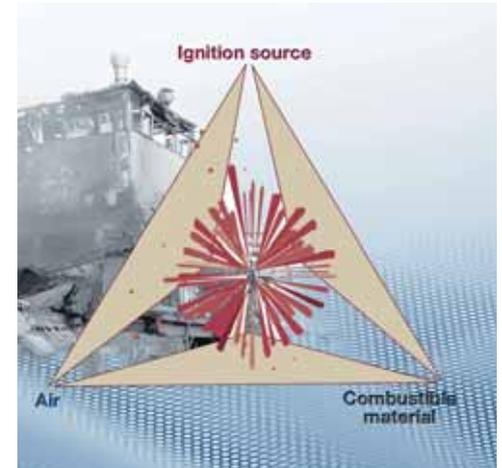
### Hazardous explosive atmosphere

An explosive atmosphere which, if it explodes, causes damages (EN 1127-1).

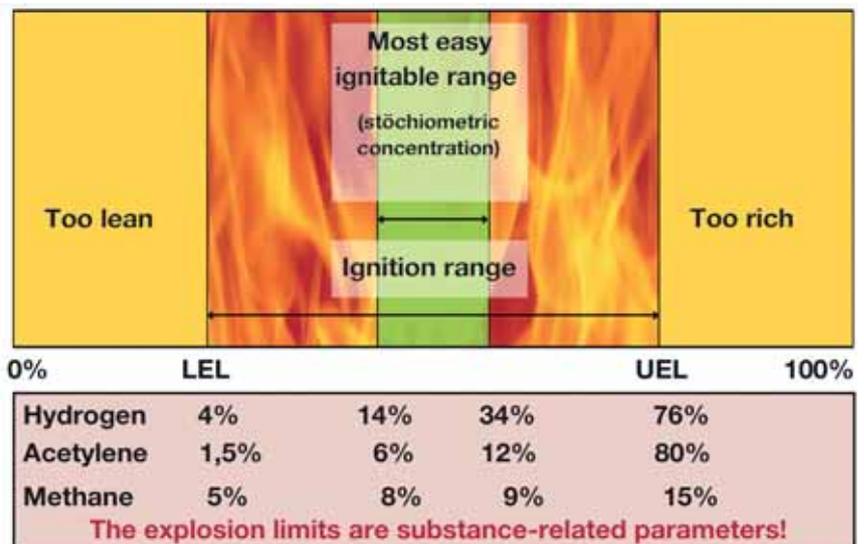
It is possible to roughly assess whether or not an atmosphere is explosive. In closed rooms, regardless of their size, 10 litres of an explosive atmosphere are already considered hazardous. In the case of smaller rooms with a volume of <100 m<sup>3</sup>, this also applies for smaller quantities.

### Ignition sources

In order to prevent the ignition of a hazardous explosive atmosphere, it is necessary to be aware of all possible ignition sources that may occur and to ensure that these ignition sources cannot become effective by applying explosion-protection measures.



Physical basics of an explosion



Ignition limit of gases and vapours in air

## Physical principles of explosion-protection

### Heat

open flames; hot surfaces; hot gases; gases under pressure; sunlight; infrared light; ultrasonic waves



### Electrical sparks

opening and closing of contacts; short circuits; over voltage; static discharges



### Mechanical sparks

friction; hammering; grinding



Here a risk assessment is carried out to analyze the probability of the simultaneous occurrence of a hazardous explosive atmosphere and an effective ignition source. Open flames and electric ignition sources have always been considered to be extremely critical and the avoidance of these ignition sources by respective protective measures has already been described in historical documents. However, in order to be able to prevent the occurrence of explosions, it is necessary to take all possible effective ignition sources into consideration.

Ignition sources that can set off an explosion are (Source EN 1127-1):

#### Hot surfaces

If an explosive atmosphere comes into contact with a heated surface, ignition can occur. Not only can a hot surface itself act as an ignition source, but a dust layer or a combustible solid in contact with a hot surface and ignited by the hot surface can also act as an ignition source for an explosive atmosphere.

#### Flames and hot gases (including hot particles)

Flames are associated with combustion reactions at temperatures of more than 1000 °C. Hot gases are produced as reaction products and, in the case of dusty and/or sooty flames, glowing solid particles are also produced. Flames, their hot reaction products or otherwise highly heated gases can ignite an explosive atmosphere. Flames, even very small ones, are among the most effective ignition sources.

#### Mechanically generated sparks

As a result of friction, impact or abrasion processes, such as grinding, particles can become separated from solid materials and become hot due to the energy used in the separation process. If these particles consist of oxidizable substances, e.g. iron or steel, they can undergo an oxidation process, thus reaching even higher temperatures. These particles (sparks) can ignite combustible gases and vapours and certain dust/air mixtures (especially metal dust/air mixtures). In deposited dust, smouldering can be caused by sparks, and this can be a source of ignition for an explosive atmosphere.

#### Electrical installations

In the case of electrical installations, electric sparks and hot surfaces can occur as sources of ignition. Electric sparks can, for example, be generated by:

- when electric circuits are opened and closed
- by loose connections
- by stray currents

#### Stray electric currents, cathodic corrosion protection

Stray currents can flow in electrically conductive systems or parts of systems:

- as return currents in power generating systems –in particular in the vicinity of electric railways and large welding systems - when, for example, conductive electrical system components that are laid in the ground, such as rails and cable sheathing, lower the resistance of this return current path
- as a result of a short circuit or of a short circuit to earth in the event of faults in the electrical installations
- as a result of magnetic induction (e.g. near electrical installations with high currents or radio frequencies) and
- as a result of lightning.

If parts of an installation able to carry stray currents are disconnected, connected or bridged, even in the case of minimal potential differences, an explosive atmosphere can be ignited as a result of electric sparks and/or arcs.

#### Static electricity

Incendive discharges of static electricity can occur under given conditions. The discharge of charged, insulated conductive parts can easily lead to incendive sparks. With charged parts made of non-conductive materials, and these include most plastics as well as some other materials, brush discharges and, in special cases, during fast separation processes or due to a combination of conductive and non-conductive materials, propagating brush discharges are also possible. Cone discharges from bulk material and cloud discharges can also occur. Brush discharges can ignite almost all explosive gas and vapour atmospheres.

# Principles of Explosion-Protection

## Physical principles of explosion-protection

### Lightning

If lightning strikes in an explosive atmosphere, ignition will always occur. Moreover, there is also a possibility of ignition due to the high temperature attained by lightning conductors. Large currents flow from where the lightning strikes and these currents can produce sparks in the vicinity of the point of impact. Even in the absence of lightning strikes, thunderstorms can cause high induced voltages in equipment, protective systems and components.

### Radio frequency (RF) electromagnetic waves from $10^4$ Hz to $3 \times 10^{12}$ Hz (high frequency)

Electromagnetic waves are emitted by all systems that generate and use radio-frequency electrical energy (radio-frequency systems), e.g. radio transmitters or industrial or medical RF generators for heating, drying, hardening, welding, cutting, etc. All conductive parts located in the radiation field function as receiving aerials. If the field is powerful enough and if the receiving aerial is sufficiently large, these conductive parts can cause ignition in explosive atmospheres. The received radio-frequency power can, for example, make thin wires glow or generate sparks during the contact or interruption of conductive parts. The energy picked up by the receiving aerial, which can lead to ignition, depends mainly on the distance between the transmitter and the receiving aerial as well as on the dimensions of the receiving aerial at any particular wavelength and RF power.

### Electromagnetic waves from $3 \times 10^{11}$ Hz to $3 \times 10^{15}$ Hz

Radiation in this spectral range can – in particular when focused, - become a source of ignition due to absorption by explosive atmospheres or solid surfaces. Sunlight, for example, can trigger an ignition if objects cause convergence of the radiation.

In the case of laser radiation, even at great distances, the energy or power density of even an unfocussed beam can be so great that ignition is possible. Here, too, the process of heating up occurs mainly when the laser beam strikes a solid body surface or when it is absorbed by dust particles in the atmosphere or on dirty transparent parts.

### Ionizing radiation

Ionizing radiation can ignite explosive atmospheres (especially explosive atmospheres with dust particles) as a result of energy absorption. Ionizing radiation can cause chemical decomposition or other reactions which can lead to the generation of highly reactive radicals or unstable chemical compounds. This can cause ignition.

### Ultrasonics

In the use of ultrasonic sound waves, a large proportion of the energy emitted by the electro-acoustic transducer is absorbed by solid or liquid substances. As a result, the substance exposed to ultrasonics heats up so intensely that, in extreme cases, ignition may be induced.

### Adiabatic compression and shock waves

In the case of adiabatic or almost adiabatic compression and in shock waves, such high temperatures can occur that explosive atmospheres (and deposited dust) can be ignited. The temperature increase depends mainly on the pressure ratio, not on the pressure difference.

**NOTE:** In pressure lines of air compressors and in containers connected to these lines, explosions can occur as a result of a compression ignition of lubricating oil mists.



## Physical principles of explosion-protection



Impact of a dust explosion:  
Rolandsmühle, Bremen, Germany

### Exothermic reactions, including self-ignition of dusts

Exothermic reactions can act as an ignition source if the rate of heat generation exceeds the rate of heat loss to the surroundings. Whether a high temperature can develop in the event of a reaction is dependent, among other parameters, on the volume/surface ratio of the reacting system, the ambient temperature and the residence time. These high temperatures can lead to both the ignition of explosive atmospheres and the initiation of smouldering and/or burning.

Such reactions include those of pyrophoric substances with air, alkali metals with water, self-ignition of combustible dusts, self-heating of feed-stuffs induced by biological processes, the decomposition of organic peroxides, or polymerization reactions.

### Flash point

#### Definition:

Lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapours in a quantity such as to be capable of forming an ignitable vapour/air mixture (IEV 426-02-14).

In accordance with the "Technical directive on flammable liquids" (TRbF), flammable liquids are divided into four classes according to their flash points.

Hazard class	Flash point
A I	<21 °C
A II	21 °C up to 55 °C
A III	>55 °C up to 100 °C
B	<21 °C, at 15 °C water-soluble

### Hazard classes

Hazard class A encompasses water-insoluble flammable liquids.

Hazard class B encompasses water-soluble flammable liquids that can be mixed with water at 15°C regardless of the ratio.

When the Operational Safety Decree (BetRSichV) came into force, this classification was replaced by the classification according to the Hazardous Substance Decree. Hazardous substances and preparations are classified as being hazardous if they feature one or more of the properties specified in § 3a, Sect. 1 of the Law on Chemical Substances and more closely defined in Annex VI of Directive 67/548/EEC. They are:

#### 1. explosive,

if, in a solid, liquid, pasty or gelatinous state, they may also react exothermically without atmospheric oxygen, thereby quickly evolving gases, and which, under defined test conditions, detonate, quickly deflagrate or, upon heating, explode when partially confined,

#### 2. oxidizing,

if they are not normally inherently combustible, but, in contact with combustible substances or preparations, mainly due to the release of oxygen, they can cause fire or enhance the risk of fire considerably,

#### 3. extremely flammable,

if they:

- in a liquid state, have an extremely low flash point and a low boiling point,
- in a gaseous state, are flammable in contact with air at ambient temperature and pressure,

#### 4. highly flammable,

if they:

- can become hot and finally catch fire in contact with air at ambient temperature without any application of energy,
- in a solid state, can readily catch fire after brief contact with a source of ignition and continue to burn or to be consumed in a hazardous manner after removal of the ignition source,
- can have a very low flash point in a liquid state,
- can evolve highly flammable gases in dangerous quantities in contact with water or damp air,

#### 5. flammable,

if they have a low flash point in a liquid state.

# Principles of Explosion-Protection

## Explosion-protection concepts (Primary and secondary explosion-protection)

### Explosion hazard

An explosion can only occur in the event of the simultaneous occurrence of a gas/air or dust/air mixture in a potentially explosive concentration and hazardous volume and an ignition source with sufficient ignition energy. This is illustrated in the "Explosion triangle" (figure).

### Primary explosion-protection

The avoidance of a hazard is always better than any protection method. Among other things, it is possible to prevent an explosion by eliminating the formation of an explosive atmosphere. Measures with this objective are known as "*Primary explosion-protection*" and shall always be given priority over other measures. Primary explosion-protection can, for example, be achieved by the following measures:

#### Avoidance of flammable substances

Whenever possible, flammable substances should be substituted by substances that are not capable of forming an explosive mixture.

#### Changing of the flash point

Here distinction is made between two procedures.

#### Raising the flash point

The flash point of a flammable liquid must be at least 5 – 15 K above the processing temperature or the room temperature. In the case of water soluble, flammable substances this can be achieved by adding water.

#### Lowering the processing temperature

With this method it is necessary to apply technical measures (e.g. cooling) to ensure that the processing temperature is always at least 5-15K lower than the flash point. It is, however, necessary to keep faults, stand-stills, leakages and other influence factors safely under control.

#### Limitation of the concentration

The formation of an explosive atmosphere can be prevented if it is possible to limit the concentration of a substance to the range below the lower or above the upper explosive limit. This can frequently be achieved with gases. Difficulties arise in the event of gas leaks or if the ignition range has to be

passed through when the plant is started or switched off. In the case of liquid substances, the concentration is usually kept below the lower explosive limit, since it requires a very high effort to keep the concentration in the upper range.

#### Inertisation

If the proportion of oxygen in a mixture is less than 10 percent by volume, then, as a general rule, an explosive mixture does not exist. In order to attain such a low proportion, so-called inert gaseous substances such as nitrogen, carbon dioxide, water steam or halogenated hydrocarbon are added to the mixture until the desired concentration is obtained. If the percent by volume of the inert gas to the flammable gas is in the minimum ratio of 25:1, an explosive atmosphere cannot build up, regardless of the quantity of air added.

#### Ventilation

The formation of a hazardous explosive atmosphere can be prevented or restricted by ventilation. In rooms above ground level and without special ventilation, the air is renewed by natural ventilation once per hour. By way of comparison, the exchange of air in cellar rooms takes up to 2.5 hours. The concentration of the mixture can, however, only be calculated if the escaping quantity per unit of time of a flammable substance is known and if an equal distribution can be assumed.

The natural flow conditions in a room can be assessed by an expert on ventilation, who will then usually recommend ventilation by technical means, as the natural ventilation cannot be considered to be a constant. Compared to natural ventilation, it ensures the exchange of larger quantities of air and a more carefully directed air flow. Moreover, the concentration occurring can be determined with a considerably higher degree of reliability.

With technical ventilation, gas clouds that are released due to faults can be quickly diluted to non-critical values. On the other hand, the drawback of ventilation by technical means is that it needs constant servicing and monitoring. In addition to this, precautions have to be taken in case the installation should operate at a lower output or fail altogether.

Definition:

### Secondary explosion-protection

After all the possibilities of primary explosion-protection have been exhausted, there can still be areas where a hazardous explosive atmosphere occurs. These areas are called hazardous areas. Here secondary explosion-protection with protective measures against ignition, which render ignition sources ineffective, are applied. Secondary explosion-protection encompasses all explosion-protection measures for electrical apparatus for use in hazardous areas.

### Constructional explosion-protection (tertiary explosion-protection)

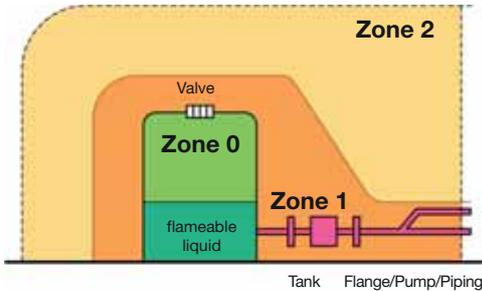
If, in spite of the measures named above, ignition sources and, as a result, explosions are to be expected, e.g. due to electrostatic discharges or chemical reactions, constructional or tertiary explosion-protection measures shall be taken.

The **explosion-protected design** is a constructional measure that cannot prevent an explosion, but can limit the effects to a non-hazardous degree. The equipment shall be designed in such a way that it can withstand the maximum explosion pressure and, in extreme case, even the detonation pressure. A detonation can happen quickly in pipes and elongated constructions. If the flame-proof design is not able to withstand the increase in pressure, effective explosion pressure relief measures shall be taken.

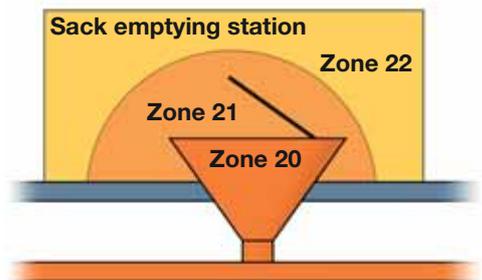


Explosion hazard triangle

## Hazardous areas



Example of the zone classification of explosive gas atmospheres to EN 60079-10-1



Example of the zone classification of explosive dust atmospheres according to EN 60079-10-2



Example of Zone 0 application: The inside of a flat-bottom tank of an oil terminal

An 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 electrical equipment (IEV 426-03-01).

### NOTE:

A hazardous area is a three-dimensional region or space (EN 60079-14).

### Zone classification

In accordance with EC-Directive 1999/92, hazardous areas are divided into six zones. The classification is based on the probability of the occurrence of an explosive atmosphere. In addition, distinction is made between flammable gases, vapours and mists on the one hand, and combustible dusts on the other. Information on the zone classification can also be found in the Explosion-Protection Rules of the Employers' Liability Insurance Association for the Chemical Industry and EN 60079-10.

### Classification of hazardous areas

#### Zone 0

An area in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently (EN 60079-14).

#### Zone 1

An area in which an explosive atmosphere consisting of a mixture of air with flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally (EN 60079-14).

#### Zone 2

An area in which an explosive atmosphere consisting of a mixture of air with 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 (EN 60079-14).

#### Zone 20

An 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 (EN 60079-14).

#### Zone 21

An 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 (EN 60079-14).

#### Zone 22

An 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 (EN 60079-14).

### NOTE:

Layers, deposits and accumulations of combustible dust are to be considered in the same way as any other source that forms an explosive atmosphere. Normal operation is understood as being the state where installations are being used within their design parameters.

### Examples of applications and the classification of suitable equipment:

#### Zone 0

Zone 0 mainly encompasses areas such as the inside of enclosed containers, pipes and apparatus that contain flammable liquids. Here the respective operating temperature lies above the flash point. The potentially explosive atmosphere is above the surface of the liquid and not in the liquid. Most gases of flammable liquids are heavier than air and spread in a similar way to liquids. Cavities such as pits or pump sumps can usually accommodate these explosive gases for longer periods, so that it is also necessary to expect a Zone 0 area here. With equipment for Zone 0, ignition sources shall be protected against explosion even if the occurrence of failures is only rare. Hence, the equipment shall satisfy the following requirements:

**Should one type of protection fail or should two faults occur simultaneously, sufficient protection against explosion shall still be ensured.**

# Principles of Explosion-Protection

## Gas-Ex areas

The constructional requirements EN 60079-26 state that the necessary explosion-protection is attained if the equipment

- is built in accordance with the type of protection "ia" to EN 60079-11, Intrinsic Safety,
- or
- satisfies the requirements of two types of protection of the series EN 60079, which are effective independently of each other.

Thus, for example, flameproof luminaires were additionally pressurized or intrinsically safe apparatus in the type of protection „ib“ were additionally potted. According to Directive 94/9/EC, equipment for Zone 0 shall satisfy the requirements for Category 1G. In Zone 0 the hazard of an ignition due to electrostatic charges, even on rare occasions, shall be safely excluded. For this reason, the requirements according to EN 60079-0 for equipment for use in Zone 0 exceed by far those for equipment for Zone 1 .

### Zone 1

Flammable or explosive substances are made, processed or stored in Zone 1. This includes the proximity of loading flap or filling and discharging facilities, the vicinity of fragile equipment, pipes and glands on pumps and slides that do not seal adequately. It is likely that an ignitable concentration will occur during normal operation.

**Ignition sources that occur during normal, trouble-free operation and those that usually occur in the event of operating disturbances shall be safely prevented.**

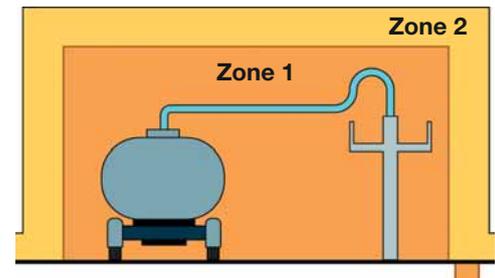
The chapter „*Electrical equipment for use in hazardous areas*“ describes the individual types of protection. According to Directive 94/9/EC, Zone 1 equipment that shall satisfy the requirements for Category 2G.

### Zone 2

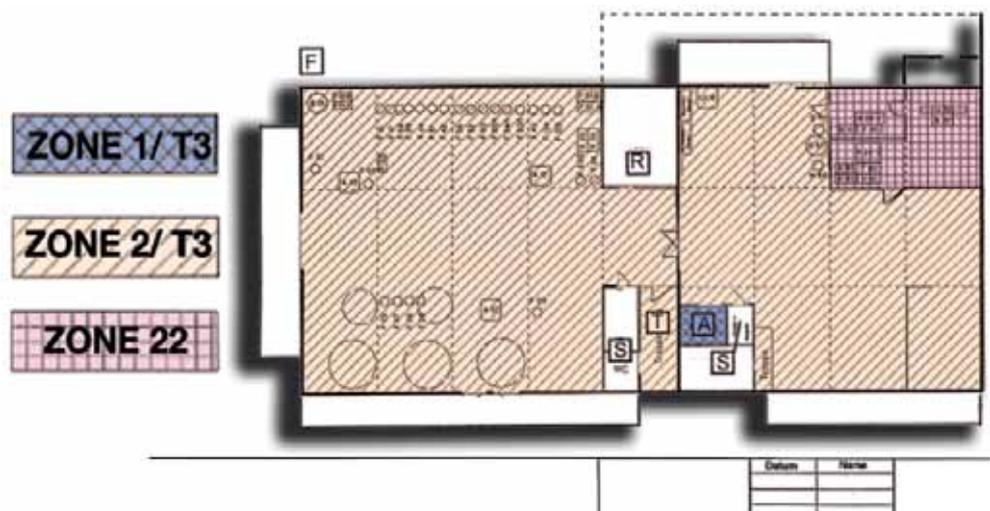
Zone 2 encompasses areas around Zone 0 and Zone 1, as well as areas around flanged joints on pipes in enclosed rooms. Furthermore, it includes such areas in which, due to natural or forced ventilation, the lower explosive limit is only attained in exceptional cases, such as the environment of outdoor installations. Flammable or explosive substances are manufactured or stored in Zone 2. The probability of the occurrence of an ignitable concentration is rare and, if one occurs, it only persists for a short period.

**During normal, trouble-free operation, ignition sources shall be safely prevented.**

According to Directive 94/9/EC, apparatus for Zone 2 shall satisfy the requirements for Category 3 G. In addition, all equipment that satisfies the requirements for equipment for use in Zone 0 and Zone 1 is permitted.



Zone classification example: Loading/discharging flammable liquids from a road transport tanker without stand-alone ventilation.



Zone classification example: Explosion-protection zone plan for explosive gas and dust atmospheres

## Dust-Ex areas



Example of dust Ex zone 21:  
Explosion-protected plug and socket and terminal box in the field

### Zone 20

Zone 20 mainly encompasses areas inside closed containers, pipes and apparatus in which combustible dust in the form of a cloud is present continuously or for long periods or frequently. With equipment for Zone 20, ignition sources shall be protected against explosions, even if the occurrence of a malfunction is rare. For this reason, equipment shall fulfil the following requirement:

**In the event of the failure of one type of protection or the simultaneous occurrence of two malfunctions, it is necessary to ensure adequate explosion-protection.**

According to Directive 94/9/EC, equipment for use in Zone 20 shall satisfy the requirements for Category 1D.

### Zone 21

Among others, Zone 21 encompasses mills, warehouses for coal or grain, and the area surrounding filling stations. Here explosive clouds of dust can develop due, for example, to the occasional escaping of dust from the opening. The risk of hazards due to dust deposits is often underestimated. Explosive dust/air mixtures can develop due to the formation of a smoulder spot or of a low temperature carbonization gas, as well as

due to the deflagration of a low temperature carbonization gas or the whirling-up of gas caused by glowing combustion.

**Ignition sources that occur during normal, trouble-free operation and those that normally occur in the event of malfunctions shall be safely prevented.**

The individual types of protection are described in the chapter „Electrical equipment for use in hazardous areas“. According to Directive 94/9/EC, equipment for Zone 21 shall satisfy the requirements for Category 2D.

### Zone 22

In Zone 22, under normal operating conditions it is unlikely that an explosive dust/air mixture will occur, but can occur, if there is a process failure and dust is lifted into the air.

**Ignition sources shall be safely prevented during normal, trouble-free operation.**

According to Directive 94/9/EC, equipment for Zone 22 shall satisfy the requirements for Category 3D. Detailed information on all zones can be found in the chapter “Construction and operation of electrical installations in hazardous areas”.



Explosive dust atmosphere

# Principles of Explosion-Protection

## EC directives on explosion-protection

### Free movement of goods within the European Community

The treaty establishing the EEC was the basis for the free movement of goods within the European economic area (Fig.: article 100 of the treaty, article 95 in the new version). In 1975, to implement this article, the Council of the European Community issued the Explosion-Protection Framework Directive (Directive 76/117/EEC).

### Directives 76/177/EEC; 79/196/EEC; 82/130/EEC

A series of European standards for explosion-protected apparatus was drawn up by the European Standards Committee for electrical apparatus (GENELEC) to provide the basis for the enforcement of the requirements.

In Germany these European standards, EN 50014 to EN 50020, were adopted as VDE standards in the national standards and came into force on 01.05.1978.

Directive 79/196/EEC of the European Committee provided the first legal basis.

This “old” directive was restricted to explosion-protected electrical equipment and the regulations that were required for the free movement of goods. By strict reference to the European standards, the normative basis for the certification of explosion-protected electrical apparatus was regulated by “notified bodies”.

These directives specified this symbol as a distinctive mark for the placing on the market of explosion-protected electrical equipment throughout the community:



## TREATY ESTABLISHING THE EUROPEAN ECONOMIC COMMUNITY from 25th March 1957

### \* Approximation of laws

#### \* Article 100

The Council, acting by means of a unanimous vote on a proposal of the Commission, shall issue directives for the approximation of such legislative and administrative provisions of the Member States as have a direct incidence on the establishment or functioning of the Common Market.

The Assembly and the Economic and Social Committee shall be consulted concerning any directives whose implementation in one or more of the Member States would involve amendment of legislative provisions.

	Directive 79/196/EEC	Directive 94/9/EC
<b>Field of application</b>	Electrical equipment Potentially explosive gas atmospheres	Electric and non-electric equipment and protective systems designed for use in explosive gas and dust atmospheres
<b>Community mark of distinction for the free movement of goods</b>		 
<b>Description</b>	Certificate of Conformity Control certificate issued by notified body	Declaration of Conformity issued by man- ufacturer Basis is a type examination certificate issued by the notified body
<b>Quality assurance system</b>	Not included	Required
<b>Operational areas and design of equipment</b>	Regulated by standards	Directly regulated in the directive - Equipment groups - Equipment categories - Fundamental safety requirements
<b>Equipment marking</b>	Regulated by standards	Stipulated in directive

## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX Directive



The purpose of this directive was the approximations of the laws of the member states of the European Union for equipment and protective systems intended for use in potentially explosive atmospheres. As of 1<sup>st</sup> of July 2003 it replaced all previous directives on explosion-protection on a European level. The four chapters of the operative part are subdivided into 16 articles. In the chapters reference is made to Annexes I to XI, which contain seven modules.

The directive, also known as the ATEX directive, applies to apparatus and protective systems that are designed for use in potentially explosive atmospheres. Safety devices and control systems for use outside of potentially explosive atmospheres also come under this directive. This applies when such devices are required for the safe operation of apparatus and protective systems in the potentially explosive area or contribute to it. Furthermore, the directive now includes “fundamental safety requirements” for explosion-protected equipment. This directive, which applies for both electrical and mechanical equipment, encompasses requirements relating to the approval of equipment and the requisite quality assurance systems. These requirements are graduated according to the equipment category. As this new directive was drawn up

according to the “new approach” of the EC, it also introduced the Declaration of Conformity issued by the manufacturer, together with the CE marking of products, for explosion-protected equipment.

### Definitions:

For the purposes of Directive 94/9/EC the following definitions, which differ in part from other definitions, shall apply for equipment and protective systems that are intended for use in potentially explosive atmospheres:

- a) “*Equipment*” are machinery, equipment, stationary or portable devices, control units and parts of equipment, as well as warning and preventive systems that, either individually or in combination, are designed for the generation, transmission, storage, measurement, control and conversion of energy and for the processing of materials that feature inherent ignition sources and are, therefore, capable of causing an explosion.
- b) “*Protective systems*” are all devices that immediately stop an explosion in its very beginning and/or limit the area covered by an explosion. They are put into circulation as independent systems. The components of the equipment defined above are not regarded as protective systems.
- c) “*Components*” are those parts that are required for the safe operation of equipment and protective systems without, however, fulfilling an independent function.

### Excluded products/applications

The following are excluded from the scope of the directive:

- medical equipment designed for use in medical areas,
- apparatus and protective systems with which an explosion hazard is only possible if explosives or chemically unstable substances are present, apparatus intended for use in domestic and non-commercial surroundings in which an explosive atmosphere can only rarely be formed, and then only as a result of an inadvertent leakage of fuel,

### Structure of Directive 94/9/EC

#### Enacting terms

Section	Article	Heading
I	1-7	Scope, placing on the market and freedom of movement
II	8-9	Conformity assessment procedures
III	10-11	CE Conformity Marking
IV	12-16	Final provisions

#### Annexes

I	Classification determining the classification of equipment groups into categories
II	Essential health and safety requirements relating to the design and construction of equipment and protective systems intended for use in potentially explosive atmospheres
III	Module: EC type examination
IV	Module: Production quality assurance
V	Module: Product verification
VI	Module: Conformity to type
VII	Module: Product quality assurance
VIII	Module: Internal control of production
IX	Module: Unit verification
X	CE marking and content of the EX Declaration of Conformity
XI	Minimum criteria to be taken into account by member states for the notification of bodies

# Principles of Explosion-Protection

## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX directive

- personal protective outfits,
- ocean-going vessels and mobile offshore plants, as well as the equipment on board these vessels or plants,
- vehicles and the associated trailers that are exclusively intended for the transportation of people by air, road, rail, or water, and transportation means designed for the transport of goods by air, public road and railway systems, or water. Vehicles intended for use in potentially explosive atmospheres are not excluded and,
- possibly, products for military purposes, if this is deemed necessary by any of the member states of the European Union.

### Essential safety requirements

The requirements relating to equipment and protective devices were divided up into general requirements and supplementary requirements, whereby, above all, the supplementary requirements are to take both existing and potential hazards into consideration. This means that the equipment and protective devices satisfy one or various requirements at the same time, inasmuch as this is necessary for their correct operation or their intended use.

Adherence to the health and safety protection requirements is absolutely essential to guarantee the safety of equipment and protective devices. These requirements shall be implemented with prudence in order to fulfil the latest technological developments at the time of placing equipment on the market. This directive only defines general basic requirements.

In order to make it easier to furnish proof that a piece of equipment or a protective system conforms to these requirements, uniform standards have been established on a European level. If standards are published by the European Commission in the official gazette of the European Communities as assigned to a given directive, they are valid as so-called "harmonized standards".

Compliance with these standards ensures that a product conforms to the basic requirements of Directive 94/9/EC (so-called "presumption principle").

Assigned to a given directive, they are valid as so-called "harmonized standards". Compliance with these standards ensures that a product conforms to the basic requirements of Directive 94/9/EC (so-called „presumption principle”).

These standards are drawn up by the European Standardization Committee (CEN) and the European Committee for Electrotechnical Standardization (CENELEC).

### Classification of explosion protected apparatus in equipment groups and categories

Cat.	Equipment Group I
M 1	<p>Equipment Group I is subdivided into the Categories M1 and M2. The equipment must continue to work even in the event of infrequent failures coinciding with an existing explosive atmosphere and must feature such protective measures against explosion so that</p> <ul style="list-style-type: none"> <li>• if one constructional protective measure fails, at least one other independent constructional measure will ensure the required safety, or</li> <li>• if two independent faults occur in combination, the required safety is still ensured.</li> </ul>
M 2	<p>If an explosive atmosphere occurs, it must be possible to switch off the equipment. The constructional explosion-protection measures ensure the required degree of safety during normal operation, even under severe operating conditions and, in particular, in cases of rough handling and changing environmental influences.</p>
Cat.	Equipment Group II
1	<p>Equipment Group II is subdivided into the Categories 1, 2 and 3. The equipment is intended for use in areas in which an explosive atmosphere is present continuously or for long periods or frequently. Even if equipment failures only occur infrequently, the equipment must ensure the required degree of safety and feature such explosion-protection measures that</p> <ul style="list-style-type: none"> <li>• if one constructional protective measure fails, at least one other independent constructional protective measure ensures the required degree of safety, or</li> <li>• if two independent faults occur in combination, the required degree of safety is still ensured.</li> </ul>
2	<p>The equipment is intended for use in areas in which an explosive atmosphere occurs occasionally. Even in the case of frequent equipment failures or faulty conditions that are normally to be expected, the constructional explosion-protection measures ensure the required degree of safety.</p>
3	<p>The equipment is intended for use in areas in which no occurrence of an explosive atmosphere due to gases, vapours, mists or whirled-up dust is to be expected. If, however, it occurs, then in all probability only rarely or for a short period. During normal operation the equipment ensures the required degree of safety.</p>

## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX directive



Example of a type label according to the latest standards and Directive 94/9/EC

### Equipment groups and equipment categories

Equipment is classified in groups and categories:

#### Equipment group

##### Equipment group I

applies to equipment intended for use in underground parts of mines and to those parts of surface installations of mines liable to be endangered by firedamp and/or combustible dust.

##### Equipment group II

applies to equipment intended for use in other places liable to be endangered by explosive atmospheres.

#### Categories

See adjacent table

### Placing on the market and commissioning of products

The member states must not forbid, restrict or impede the placing on the market and commissioning of equipment, protective systems and devices that conform to the terms of this directive. Similarly, the placing on the market of components covered by a certificate of conformity shall not be forbidden, restricted or impeded if they are to be built into a piece of equipment or a protective system in line with this directive.

The EU member states assume conformity with this directive and with the conformity assessment procedures if the apparatus, protective systems and devices are accompanied by the EC Certificate of Conformity and if the products are provided with the CE mark.

Products that do not yet meet the requirements of this directive may be displayed at exhibitions, fairs and demonstrations, if a visible label clearly points to the fact that it will not be possible to purchase the product until compliance with the directive has been ensured.

### Procedure for unsafe products

Should a member state discover that any apparatus, protective systems or devices

with CE mark are unsafe; it can withdraw these from the market and forbid their being put into circulation or commissioning, or restrict their free circulation.

Equipment, protective systems or devices are regarded as unsafe if, when used for their intended purpose, they represent an imminent danger to the safety of people, domestic animals or goods.

The member state is required to notify the commission of the European Union of such measures and to give the reasons for its decision. The commission will immediately contact the companies concerned and inform all member states if these measures are justified.

If the fault is the result of a standard, a committee will deal with it. Great importance is attached to the uniformity of the practical implementation. The standing committee will review questions relating to the application of this directive.

### Marking

Each piece of equipment and each protective system shall be marked in a clear and indelible manner with the following minimum data:

- manufacturer's name and address
- CE marking and number of Notified Body, responsible for the monitoring of the quality system
- designation of the series and type
- serial number, if required
- the year of construction
- the special marking for explosion-protected equipment together with the marking showing the category
- the letter "G" for apparatus group II for areas in which explosive mixtures of gas, vapour or mist with air mixtures are present
- and/or the letter "D" for areas where an explosive atmosphere can form due to dust.

In addition and where required, any details that are indispensable for the safety of operation also have to be affixed.

### Examples of markings:

<b>II 1G</b>	Equipment group II Category 1 (Zone 0 equipment) (G = gases, vapours, mists)
<b>II 2G</b>	Equipment group II Category 2 (Zone 1 equipment) (G = gases, vapours, mists)
<b>II 3G</b>	Equipment group II Category 3 (Zone 2 equipment) (G = gases, vapours, mists)
<b>II 1D</b>	Equipment group II Category 1 (Zone 20 equipment) D = dust
<b>II 2D</b>	Equipment group II Category 2 (Zone 21 equipment) D = dust
<b>II 3D</b>	Equipment group II Category 3 (Zone 22 equipment) D = dust

# Principles of Explosion-Protection

## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX directive

### CE marking

Products that fall within the scope of given directives shall be provided with the CE mark by the manufacturer. This applies to products that are covered by the directives according to the new concept and include requirements relating to the technical properties of products. These EC directives constitute binding regulations of the „European Union“. This means that compliance with these requirements is the condition for marketing the products in Europe. When a product is provided with the CE marking, the conformity of the product with the relevant basic requirements of all directives applicable to the products is confirmed. The marking is, therefore, an imperative requirement for the placing on the market of products within the Community, as well as in the country of origin.

The CE marking is only meant as evidence of conformity with the directives for the supervising authorities and is not a quality mark.

The following directives are of special importance for electrical equipment:

### Directive 2006/95/EC

Electrical equipment for use within defined voltage limits (Low voltage directive)

### Directive 2004/108/EC

Electromagnetic compatibility (EMC directive)

### Directive 2006/42/EC

Safety of machinery (Machinery directive)

### Directive 1999/5/EC

Telecommunication equipment (R&TTE directive)

### Directive 94/9/EC

Equipment and protective systems for use in potentially explosive atmospheres (ATEX Directive)

When assessing which directives are to be applied to explosion-protected apparatus, it is necessary to differentiate between whether these directives are to be applied generally or only to certain products.

### Directive 2006/95/EC

**This directive does not apply to “Electrical apparatus for use in explosive atmospheres”**

(Exclusion as per Annex II of the directive)

### Directive 2004/108/EC

This directive is to be applied to any products that may cause electromagnetic interferences or the operation of which may be impaired by such interferences

### Directive 2006/42/EC

Clauses 4 and 5 of Article 1 of the directive clearly state that this directive shall not be applied to explosion-protected electrical equipment

### Directive 1999/5/EC

This directive may only be applied to “Electrical equipment for use in potentially explosive atmospheres” to a very limited degree (products for connection to the public telecommunications network).

### Directive 94/9/EC

This directive is to be applied to all products (including non-electric products) for use in a potentially explosive atmosphere. In addition to marking products with the CE mark, the manufacturer shall issue a Declaration of Conformity for the product. This Declaration of Conformity shall clearly state which directive was applied and according to which standards the tests were carried out.



## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX directive



### Conformity assessment procedures for equipment according to Directive 94/9/EC

Depending upon the conformity assessment procedure to be applied, a notified body can be active during the design and engineering phase, during the production phase or during both phases. The applicable evaluation procedure is laid down in Directive 94/9/EC according to the product, the group and the equipment category.

#### Equipment Groups I and II, Equipment Categories M1 and 1

In order to be permitted to affix the CE mark to his product, the manufacturer must arrange for the following procedures to be carried out:

- EC-type examination by a notified body and either
- an audit of the quality assurance for the production process or
- an audit of the products.

#### Equipment Groups I and II, Equipment Categories M2 and 2

With internal combustion motors and electrical apparatus, in order to be permitted to affix the CE mark on the product, the manufacturer must arrange for the following procedures to be carried out and/or ensure the following measures:

- EC-type examination by a notified body and
- either guarantee of constructional conformity or
- verification of the required quality level by means of the quality assurance procedure for the products.

The internal production control procedure shall be applied for all other equipment in these groups and categories.

#### Equipment Group II, Equipment Category 3

In order to be permitted to affix the CE mark to the product, the manufacturer shall apply the internal production control procedure.

#### Declaration of Conformity

In order to place products on the market within the EU, the EC Declaration of Conformity shall be included with all products or batches of identical products. This does not apply to the report issued by the notified body as part of the audit of the quality assurance system of the manufacturer or the EC-Type Examination Certificate.

### Conformity assessment procedure

Equipment Group	I and II	I and II	I and II	II
Category	M 1 and 1	M 2 and 2	M 2 and 2	3
Field of Application	<ul style="list-style-type: none"> <li>• any apparatus</li> <li>• if applicable safety and control devices</li> <li>• components (*)</li> <li>• independent protective systems</li> </ul>	<ul style="list-style-type: none"> <li>• electrical apparatus</li> <li>• if applicable, safety and control devices</li> <li>• components (*)</li> <li>• I.C. engines</li> </ul>	<ul style="list-style-type: none"> <li>• other apparatus</li> <li>• components (*)</li> </ul>	<ul style="list-style-type: none"> <li>• any apparatus</li> <li>• safety and control devices</li> <li>• components (*)</li> </ul>
Combination of procedures acc. to Annexes III to IX	EC type sample test to Annex III plus quality assurance of production acc. to Annex IV or inspection of products acc. to Annex V	EC type sample test to Annex III plus quality assurance of product acc. to Annex VIII or conformity with design IV	Internal production control acc. to Annex VIII plus submitting of technical documents to the designated test lab	Internal production control acc. to Annex VIII

#### Alternative: Individual EC test acc. to Annex IX

(\*) Components without affixed CE marking

# Principles of Explosion-Protection

## Directive 94/9/EC of the European Parliament and Council dated March 23, 1994 - ATEX directive

### Operating instructions

Operating instructions with the following minimum data shall be available for every piece of equipment or protective system:

- The same details as those required for the marking of equipment or protective systems - with the exception of the serial number - and, if any information relating to the servicing (e.g. the address of the importer or service centres, etc.)
- Details on the safe
  - commissioning,
  - use
  - assembly and disassembly
  - maintenance (servicing and trouble shooting)
  - installation and commissioning
- Where necessary, the marking of hazardous areas in front of pressure relief devices
- Where necessary, details on training
- Details which allow a decision to be taken beyond any doubt as to whether an item of equipment (in a specific category) or a protective system can be used safely in the intended area under the expected operating conditions
- Electrical and pressures parameters, maximum surface temperatures and other limit values
- Where necessary, specific conditions of use, including details of possible misuse, which experience has shown might occur
- Where necessary, the essential characteristics of tools that can be mounted on the equipment or protective system.

The operating instructions shall be drawn up by the manufacturer or his authorized representative established in the community in one of the community languages. If necessary, a translation into the local language of the operational site shall be made by either the manufacturer, his authorized representative established in the Community or from the person introducing the equipment or protective system into the respective language area.

The maintenance instructions for use by the specialist personnel employed by the manufacturer or his authorized representative established in the Community may be drawn up in a single Community language that is understood by this personnel.

The operating instructions contain the drawings and diagrams that are necessary for the putting into service, maintenance, inspection, checking of correct operation and, when appropriate, repair of equipment and protective systems, together with all useful instructions, in particular with regard to safety.

With regard to safety aspects, the documentation describing the equipment and protective systems shall not contradict the operating instructions.



eLLK explosion-protected light fitting for ceiling mounting with operating instructions



### National law

The member states of the EU have transposed Directive 94/9/EC into national law. Here it is necessary to observe the national ruling of the individual countries.



## Directive 1999/92/EC



### Structure of Directive 1999/92/EC Enacting terms

Section	Article	Heading
I	1-2	General requirements
II	3-9	Duties of employer
	3	Prevention of and protection against explosions
	4	Assessment of the explosion risks
	5	General obligations
	6	Coordination obligations
	7	Areas with explosive atmospheres
	8	Explosion-protection document
	9	Special regulations relating to working materials and places of work
III	10-15	Other requirements
<b>Annex I</b>		<b>Classification of areas where explosive atmospheres may occur</b> 1. Areas where explosive atmospheres may occur 2. Classification of hazardous areas
<b>Annex II A</b>		<b>Minimum requirements for the improvement of the safety and health protection of employees potentially at risk from explosive atmospheres</b>  1. Organizational measures 2. Explosion-protection measures
<b>Annex II B</b>		<b>Criteria for the selection of equipment and protective systems</b>
<b>Annex III</b>		<b>Warning signs for marking areas where explosive atmospheres may occur</b>

### Directive 1999/92/EC of the European Parliament and Council dated December 16, 1999

(Minimum requirements for the improvement of the safety and health protection of employees potentially at risk due to an explosive atmosphere)

Explosion-protection is of particular importance to safety. Explosions endanger the lives and health of workers as a result of the uncontrolled effects of flame and pressure, the presence of noxious reaction products and consumption of the oxygen in the ambient air which workers need to breathe;

For this reason, in order to establish a coherent strategy for the prevention of explosions at the workplace, organizational measures have to be taken. Directive 89/391/EEC requires the employer to take the necessary measures for the health and safety protection of employees, including measures for the prevention of occupational hazards, to inform and instruct, and to provide a suitable organization and the necessary means.

The directive was issued in accordance with Article 137 of the treaty establishing the EEC and is, as such, only a minimum requirement. It states explicitly that any provisions issued on the basis of this article shall not prevent the member states from maintaining or taking more stringent protective measures that are compatible with the treaty.

#### Scope:

This Directive, which is the 15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC, lays down minimum requirements for the safety and health protection of workers potentially at risk from explosive atmospheres.

This Directive shall not apply to:

- a) areas used directly for and during the medical treatment of patients;
- b) the use of appliances burning gaseous fuels in accordance with Directive 90/396/EEC (2);
- c) the manufacture, handling, use, storage and transport of explosives or chemically unstable substances;

# Principles of Explosion-Protection

## Directive 1999/92/EC

d) mineral-extracting industries covered by Directive 92/91/EEC (3) or Directive 92/104/EEC (4);

e) the use of means of transport by land, water and air, to which the pertinent provisions of the international agreements (e.g. ADNR, ADR, ICAO, IMO, RID), and the Community Directives giving effect to those agreements apply.

Means of transport intended for use in a potentially explosive atmosphere shall not be excluded.

### Reduction and assessment of explosion risks

It is the duty of the employer to carry out measures in the following order of precedence:

1. Prevention of explosive atmospheres, where possible by the substitution of materials.
2. Prevention of the ignition of explosive atmospheres.
3. Mitigation of harmful effects.

This concept is already known in Germany due to the explosion-protection directives of the employers' liability insurance association and it has been put into practice for many years. The new aspect of this directive is the systematic method according to which the measures are laid down and documented.

After assessment of all the remaining explosion risks, whereby the interaction of installations, the materials being used, the processes and their possible interactions were taken into consideration, measures for the safety of employees at work must be laid down to ensure their health and safety at all times.

Here special requirements are imposed regarding the coordination duties of the employer at the place of work.

### Classification of hazardous areas

The areas in which explosive atmospheres can occur are subdivided into zones according to the frequency and duration of the occurrence of explosive atmospheres. This classification determines the scope of the measures to be taken.

#### Zone 0

A 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.

#### Zone 1

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

#### Zone 2

A 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.

#### Zone 20

A place 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.

#### Zone 21

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

#### Zone 22

A place 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.

#### NOTE:

With combustible dusts, it is also necessary to consider the layers, deposits and accumulations as a source for possible explosive atmospheres. Normal operation is understood as being when installations are used according to the specified parameters.

1. Layers, deposits and accumulations of combustible dust that can form an explosive atmosphere shall be treated in the same way as any other cause.
2. Normal operation is the state in which installations are used within the rated parameters.

## Directive 1999/92/EC

### Explosion-protection document

In carrying out his obligations, the employer shall ensure that a document (hereinafter referred to as the 'explosion-protection document') is drawn up and kept up to date.

In particular, the explosion-protection document shall demonstrate,

- that the explosion risks have been determined and assessed
- that adequate measures will be taken to attain the aims of this Directive
- which areas which have been classified into zones in accordance with Annex I
- the areas where the minimum requirements set out in Annex II apply
- that the workplace and work equipment, including warning devices, are designed, operated and maintained with due regard for safety
- that, in accordance with Council Directive 89/655/EEC (1), arrangements have been made for the safe use of work equipment

The explosion-protection document shall be drawn up prior to commencement of work and shall be revised when the workplace, work equipment or organisation of the work undergoes significant changes, extensions or conversions.

The employer may combine existing explosion risk assessments, documents or other equivalent reports produced under other Community acts.

### Annex II A

Minimum requirements for the improvement of the safety and health protection of employees potentially at risk from explosive atmospheres.

#### 1. Organizational measures

- Appropriate instruction of employees
- Written instructions and work release notes
- If necessary, written instructions for work assignment
- Work release system for hazardous tasks
- Work release by authorized person

#### 2. Explosion-protection measures

- Rendering any escaped Ex-atmosphere harmless
- Design according to the highest risk potential
- Avoidance of all ignition hazards (e.g. static charge of persons)
- Taking into operation if authorized in the explosion document
- Installation and operation according to the lowest explosion risk
- If necessary, warning of Ex-atmosphere (visual/acoustical)
- Provision of escape facilities
- Initial inspection by qualified persons
- Measures for risk assessment
- Hazards due to power failures
- Safe reduction of stored energy

### Annex II B

Criteria for the selection of equipment and protective systems:

Unless otherwise specified in the explosion-protection document, taking into account the risk evaluation, equipment and protective systems are selected in accordance with Directive 94/9/EC.

Zone	Category
0 or 20	1
1 or 21	1 or 2
2 or 22	1, 2 or 3

### Annex III

Warning sign for marking areas in which explosive atmospheres may occur.



# Principles of Explosion-Protection

## Electrical equipment for use in hazardous areas: Fundamentals

### Electrical equipment for use in hazardous areas

#### Fundamentals

#### Classification in groups

It would not be economical to build all explosion-protected electrical equipment in such a way that it can be used in all areas (groups). Furthermore, there are also other boundary conditions, e.g. relating to the ignition temperature, the flame transmission properties and the ignitability of the explosive substance. For this reason, electrical equipment is subdivided into explosion groups and temperature classes.

Group I:  
encompasses electrical equipment for use in mines susceptible to firedamp such as coal mines.

Group II:  
encompasses electrical equipment for use in explosive gas atmospheres

Group III:  
encompasses electrical apparatus for use in all explosive dust atmospheres

#### Classification of gases and vapours

Group II electrical equipment is subdivided into A, B, and C. In the case of flameproof enclosures, the classification is based on the maximum experimental safe gap (MESG) and, in the case of intrinsically safe apparatus on the minimum ignition current (MIC). Furthermore, with all equipment, it is also necessary to take the subdivision into groups with regard to the risk of electrostatic charges/discharges into consideration. Similarly, the hazards due to electromagnetic and optical radiation shall also be taken into account.

#### Classification of dusts

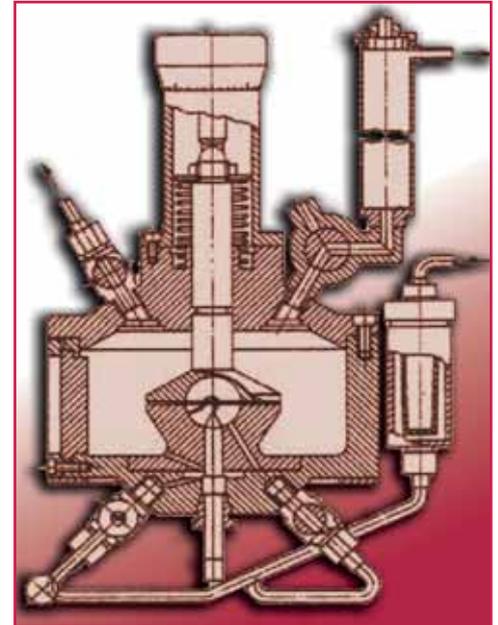
Based on the same principles as those for the subdivision of electrical equipment in Group II, electrical equipment of Group III is also subdivided into groups A, B and C. Here the classification is based on the properties of the "dust".

III A combustible flyings  
III B non-conductive dust  
III C conductive dust

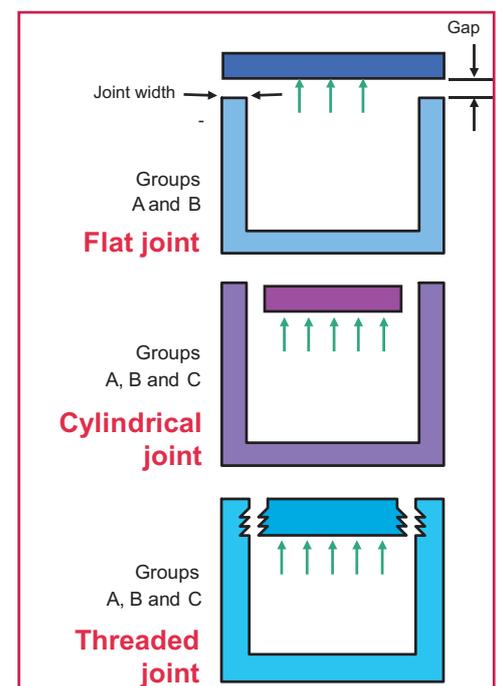
#### Maximum experimental safe gap (MESG)

##### Definition:

The maximum gap of the joint between the two parts of the interior chamber of a test apparatus which, under specified conditions, when the internal gas mixture is ignited, prevents ignition of the external gas mixture by flame propagation through a joint measuring 25 mm in length.



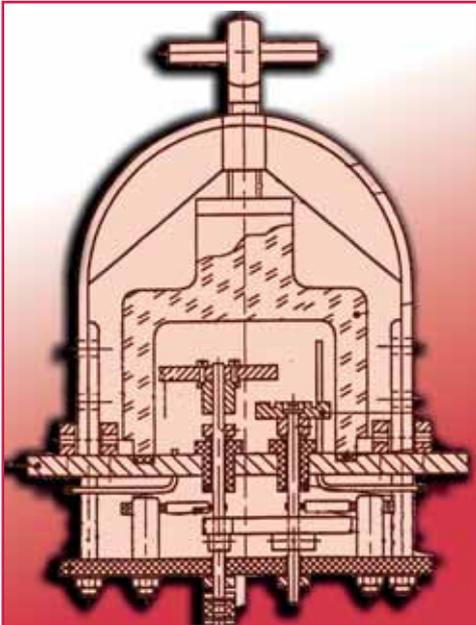
Experimental setup for the determination of the MESG (maximum experimental safe gap) in accordance with IEC 60079-20-1.



Types of joints, used in practice:  
flat joint, cylindrical joint, threaded joint

Group	Safe gap in mm	MIC ratio
II A	> 0,9	> 0,8
II B	0,5 up to 0,9	0,45 up to 0,8
II C	< 0,5	< 0,45

## Electrical equipment for use in hazardous areas: Fundamentals



Experimental setup for determining the MIC (minimum ignition current)

### Minimum ignition current (MIC)

A minimum ignition energy is needed to ignite an explosive mixture. Due to an external ignition source, e.g. an electric spark, a high temperature develops in a small volume area of an explosive atmosphere. This then leads to combustion. The heat generated by the spark and the subsequent combustion heats the immediate layers, but, at the same time, energy is fed to the outside due to heat conduction.

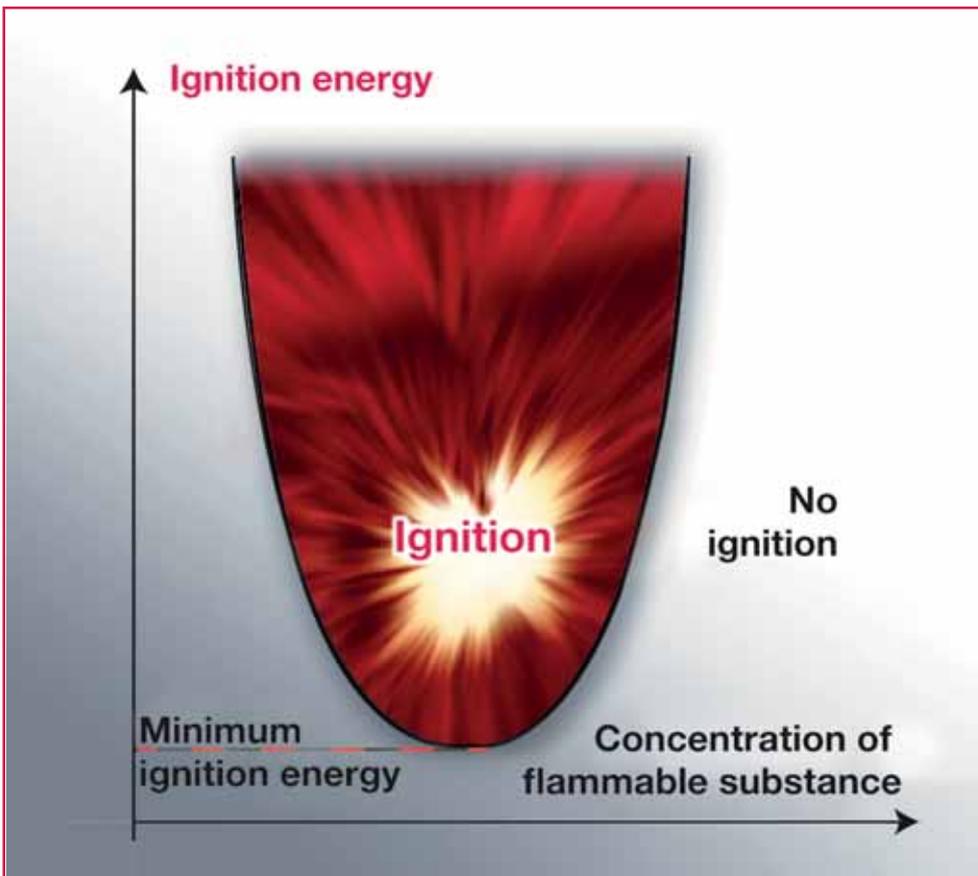
If the heat dissipation is greater than the quantity of heat that is supplied and generated, a propagation of the combustion to the surrounding volume areas is not possible. Only if, due to the external ignition source, the energy input is so great that the temperature of the surrounding layers rises above its ignition temperature, the combustion is propagated autonomously and an explosion occurs.

This basic knowledge is used for the type of protection "Intrinsic Safety". The electric ratings of a circuit are limited to such a degree that the minimum ignition energy required for an ignition is not attained.

### Minimum ignition energy:

The smallest amount of electrical energy stored in a capacitor that, in the event of the discharge of this capacitor across a spark gap, is barely able to ignite the most easily ignitable fuel/air mixture at atmospheric pressure and room temperature. The safe gap and minimum ignition current ratio are related in a certain manner.

In order to be able to classify gases and vapours to satisfy the explosion-protection requirements, with most of the mixtures of gas and vapour with air that are used in industry it is, therefore, sufficient to determine just one of the two properties.



Ignition energy in relation to the concentration of a flammable substance in air

# Principles of Explosion-Protection

## Electrical equipment for use in hazardous areas: Fundamentals

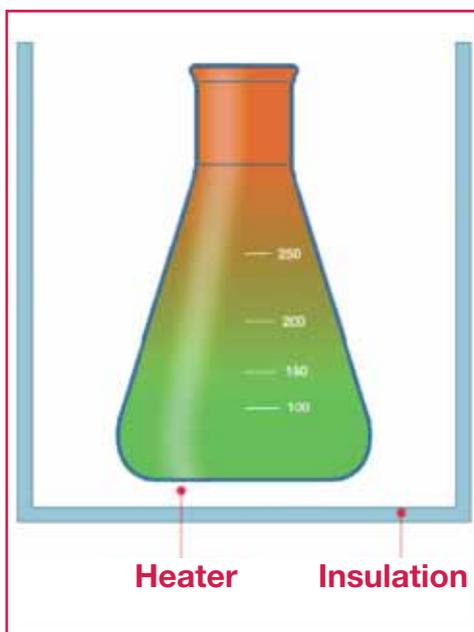
### Ignition temperature and temperature classes

The maximum surface temperature of the electrical apparatus must not attain the ignition temperature of the explosive atmosphere. It goes without saying that apparatus that fulfils the requirements of temperature class T3 is also suitable for use in explosive atmospheres in the temperature classes T1 and T2.

The ignition temperature of a flammable substance is determined by means of a test apparatus. It is the lowest temperature on a heated wall at which the flammable substance will just about ignite in a mixture with air.

Data on this can be found in IEC TR 60079-20. The ignition temperatures of the different explosive mixture vary considerably. Whereas a mixture of air with town gas will only ignite at 560 °C, a mixture of air and petrol will ignite at ca. 250 °C.

These properties led to a classification and, with it, a subdivision into temperature classes.



Experimental determination of the ignition temperature of flammable substances in accordance with IEC 60079-20 f

Temperature class	Max. admiss. surface temperatures on group II electrical apparatus	Ignition temperatures of inflammable substances in °C
T 1	450	> 450
T 2	300	> 300 ≤ 450
T 3	200	> 200 ≤ 300
T 4	135	> 135 ≤ 200
T 5	100	> 100 ≤ 135
T 6	85	> 85 ≤ 100

### Classification of gases and vapours in explosion groups and temperature classes

	T 1	T 2	T 3	T 4	T 5	T 6
<b>I</b>	Methane					
<b>II A</b>	Acetone Ethane Ethylacetate Ammonia Benzol Acetic acid Carbon oxide Methanol Propane Toluene	Ethyl alcohol i-amyl acetate n-butane n-butyl alcohol	Petrol Diesel fuel Aviation fuel Heating oils n-Hexane	Acetaldehyde Ethylether		
<b>II B</b>	Town gas (lamp gas)	Ethylene				
<b>II C</b>	Hydrogen	Acetylene				Carbon disulphide

## Electrical equipment for use in areas with combustible dust



Explosion protected searchlight inside the dust test chamber

### Electrical equipment for use in areas with combustible dust

#### Ignition sources

Combustible dust can be ignited by electrical apparatus in various ways:

- by apparatus surface temperatures that are higher than the ignition or glow temperature of the respective dust. The temperature at which the dust ignites is dependent on the properties of the dust, on whether it is present in the form of a cloud or deposits, on the thickness of the layer and on the type of heat source
- by sparks at electrical parts such as switches, contacts, commutators, brushes or similar
- by the discharge of stored electrostatic energy
- by radiated energy (e.g. electromagnetic radiation)
- by magnetic impact or friction sparks or a rise in temperature originating from the apparatus.

To avoid ignition hazards, it is necessary that:

- the temperature of any surfaces on which dust deposits can form or that can come into contact with a cloud of dust are kept at a temperature that is lower than the limiting temperatures laid down in EN 50028-1-2
- all parts with electric sparks or with temperatures above the ignition or glow temperature of the dust are built into an enclosure that prevents the ingress of dust in a suitable manner, or
- the energy of the electric circuits is limited to such a degree, that sparks or temperature that could ignite combustible dust are avoided
- all other ignition sources are avoided.



# Principles of Explosion-Protection

## Equipment protection level EPL

### Introduction of an alternative risk assessment method incorporating „equipment protection levels“ for Ex equipment

The concept of a risk assessment method has been introduced into the standards as an additional method. The equipment protection level (EPL) concept is based on the categories described in Directive 94/9/EC.

### Historical background

Not all types of protection provide the same level of security against the possibility of the occurrence of an incendive condition. In the standard EN 60079-14, „Electrical installations design selection and erection“, specific types of protection are allocated to specific zones on the statistical basis that the more likely or frequent the occurrence of an explosive atmosphere, the greater the level of security against the possibility of an ignition source being active.

Hazardous areas are divided into zones according to the degree of hazard. The degree of hazard is defined according to the probability of the occurrence of an explosive atmosphere. Generally, neither the potential consequences of an explosion nor other factors, such as the toxicity of materials, are taken into account. A true risk assessment would consider all factors.

Historically, the selection of equipment for each zone is based on the type of protection. In some cases the type of protection may be divided into different categories which historically correlate to zones. For example, intrinsic safety was divided into the categories ia and ib and the application thereof allocated directly to zones

### General

A risk assessment approach for the acceptance of Ex equipment has been introduced as an alternative to the prescriptive and relatively inflexible approach linking equipment to zones. To facilitate this, a system of equipment protection levels (EPLs) has been introduced to clearly define the inherent ignition risk of equipment, no matter what type of protection is applied.

The system of designating these equipment protection levels is as follows

### Mines susceptible to firedamp (Group I)

#### EPL „Ma“

Equipment for installation in mines susceptible to firedamp with a „very high“ level of protection, which has sufficient security that it is unlikely to become an ignition source, even when left energized in the presence of an outbreak of gas.

#### EPL „Mb“

Equipment for installation in mines susceptible to firedamp with a „high“ level of protection, which has sufficient security that it is unlikely to become a source of ignition in the time span between there being an outbreak of gas and the equipment being de-energized.



Picture: Ruhrkohle-AG

## Equipment protection level EPL

Equipment protection level	Zone
Ga	0
Gb	1
Gc	2
Da	20
Db	21
Dc	22

Traditional relationship of EPLs to zones  
(no additional hazard assessment)

### Gases (Group II)

#### EPL „Ga“

Equipment for explosive gas atmospheres with a “very high” level of protection, which is not a source of ignition in normal operation or during malfunctions which cannot necessarily be expected on a regular basis.

#### EPL „Gb“

Equipment for explosive gas atmospheres with a “high” level of protection, which is not a source of ignition in normal operation or during malfunctions, which cannot necessarily be expected on a regular basis.

#### EPL „Gc“

Equipment for explosive gas atmospheres with an “enhanced” level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular, expected occurrences (e.g. failure of a lamp).

### Dusts (Group III)

#### EPL „Da“

Equipment for explosive dust atmosphere with a “very high” level of protection, which is not a source of ignition in normal operation or during rare malfunctions.

#### EPL „Db“

Equipment for explosive dust atmosphere with a “high” level of protection, which is not a source of ignition in normal operation or during malfunctions which cannot necessarily be expected on a regular basis.

#### EPL „Dc“

Equipment for explosive dust atmosphere with an “enhanced” level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular, expected occurrences (e.g. failure of a lamp).

For the majority of the situations with the typical possible consequences of the occurrence of an explosion, it is planned that the following apply for the use of equipment in zones (this cannot be applied directly for mines, because the zone concept is not generally valid):

### Comparison of EPL and category

Equipment protection level		Category
EPL Ma	n	I 1 M
EPL Mb	n	I 2 M
EPL Ga	n	II 1 G
EPL Gb	n	II 2 G
EPL Gc	n	II 3 G
EPL Da	n	II 1 D
EPL Db	n	II 2 D
EPL Dc	n	II 3 D



# Principles of Explosion-Protection

## Description of the protection afforded against the occurrence of an ignition

Protection afforded	Equipment protection level	Performance of protection	Condition of operation
	Group		
Very high	Ma	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning when explosive atmosphere present
	Group I		
Very high	Ga	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning in zones 0, 1 and 2
	Group II		
Very high	Da	Two independent means of protection or safe even when two malfunctions occur independently of each other	Equipment remains functioning in zones 20, 21 and 22
	Group III		
High	Mb	Suitable for normal operation and severe operating conditions	Equipment de-energized when explosive atmosphere present
	Group I		
High	Gb	Suitable for normal operation and frequently occurring disturbances or equipment where malfunctions are normally taken into account	Equipment remains functioning in zones 1 and 2
	Group II		
High	Db	Suitable for normal operation and frequently occurring disturbances or equipment where malfunctions are normally taken into account	Equipment remains functioning in zones 21 and 22
	Group III		
Enhanced	Gc	Suitable for normal operation	Equipment remains functioning in zone 2
	Group II		
Enhanced	Dc	Suitable for normal operation	Equipment remains functioning in zone 22
	Group III		

## Description of the protection afforded against the occurrence of an ignition

EPL	Type of protection	Symbol	Standards
„Ga“	Intrinsic safety	„ia“	IEC 60079-11
	Encapsulation	„ma“	IEC 60079-18
	Two independent types of protection, each fulfilling requirements of EPL „Gb“		IEC 60079-26
	Protection of equipment and transmission systems using optical radiation	„op is“	IEC 60079-28
„Gb“	Flameproof enclosure	„d“	IEC 60079-1
	Increased safety	„e“	IEC 60079-7
	Intrinsic safety	„ib“	IEC 60079-11
	Encapsulation	„mb“	IEC 60079-18
	Oil immersion	„o“	IEC 60079-6
	Pressurization	„px“ or „py“	IEC 60079-2
	Powder filling	„q“	IEC 60079-5
	Field bus intrinsically safe concept (FISCO)		IEC 60079-27
	Protection of equipment and transmission systems using optical radiation	„op pr“	IEC 60079-28
„Gc“	Intrinsic safety	„ic“	IEC 60079-11
	Encapsulation	„mc“	IEC 60079-16
	Non-sparking	„nA“	IEC 60079-15
	Restricted-breathing	„nR“	IEC 60079-15
	Energy limitation	„nL“	IEC 60079-15
	Sparking apparatus	„nC“	IEC 60079-15
	Pressurization	„pz“	IEC 60079-2
	Field bus non-incendive concept (FISCO and FNICO)		IEC 60079-27
	Protection of equipment and transmission systems using optical radiation	„op sh“	IEC 60079-28
„Da“	Intrinsic safety	„ia“	IEC 60079-11
	Encapsulation	„ma“	IEC 60079-18
	Protection by enclosure	„ta“	IEC 60079-31
„Db“	Intrinsic safety	„ib“	IEC 60079-11
	Encapsulation	„mb“	IEC 60079-18
	Protection by enclosure	„tb“	IEC 60079-31
	Pressurization	„pD“	IEC 61241-4
„Dc“	Intrinsic safety	„ic“	IEC 60079-11
	Encapsulation	„mc“	IEC 60079-16
	Protection by enclosure	„tc“	IEC 60079-31
	Pressurization	„pD“	IEC 61241-4

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### Types of protection

#### EN 60079-0

#### Explosive atmospheres - Part 0: General requirements

Electrical equipment for use in hazardous areas shall satisfy the general requirements of EN 60079-0 and the specific requirements of the respective type of protection in which it is designed. Particularly harsh operating conditions, the effects of humidity, high ambient temperatures and other special stresses might require special additional measures.

Special requirements specified in the standards are to be observed for the use of plastics and light alloys, in particular for enclosures.

The mechanical stability, suitability for the intended operating temperature and ageing resistance of the enclosure materials used are verified by means of climatic conditioning, impact and drop tests.

To prevent electrostatic charges when using plastics, if the surfaces exceed those specified in the standard, normally a material with a surface resistance of  $< 1 \text{ G}\Omega$  is used.

Depending on the type of protection, special requirements apply for:

- fasteners and interlocks,
- bushings and connection pieces,
- cable entries
- and conduit.

#### EN 60079-1

#### Explosive atmospheres- Part 1: Equipment protection by flameproof enclosure "d"

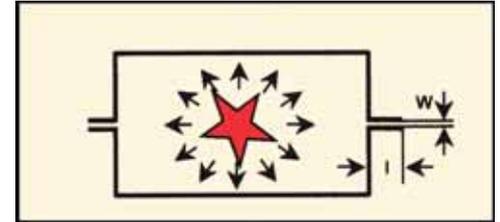
#### Definition:

Type of protection where the parts which can ignite an explosive gas atmosphere are built into a flameproof enclosure that can withstand the pressure developed during an internal explosion of an explosive mixture and prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

The flameproof enclosure principle can be compared to a one-way street. An explosive atmosphere can penetrate into the enclosure of the electrical apparatus, but, in the event of an explosion inside the enclosure, transmission of the explosion to the explosive atmosphere surrounding the enclosure is prevented. As, due to the construction principle, normally there are gaps in flameproof enclosures, these gaps shall be such that an arc-through through these gaps is prevented. The geometry of gaps, the gaps and the width of joints shall vary according to the respective group (A, B, C). The values stated in the standard are only minimum requirements. The suitability shall be verified by experiment.

The flameproof enclosure shall be able to safely withstand the pressure arising from an explosion inside the enclosure. Depending upon the size, group and geometry, the pressures arising in the event of an explosion can vary considerably ( $< 5 \text{ bar}$  to  $> 40 \text{ bar}$ ). If flameproof enclosures are used outside of the standard ambient temperature range ( $-20^\circ\text{C}$  to  $+40^\circ\text{C}$ ), the suitability shall be tested in accordance with the method specified in EN 60079-1.

Special attention shall be given to the fact that, as the ambient temperature changes, there may also be negative changes to the stability of enclosure parts. Because, when the internal compartment is divided up (e.g. by built-in equipment) and, in the event of an explosion, a precompaction of the remaining mixture and, as a result, increases in pressure may occur, the worst case scenarios shall be taken into consideration during experiments.



Principle of flameproof encapsulation



Rotary switch in flameproof enclosure of the series GHG 64 with flat joint and flanged-on Ex-e connection box for indirect connection

## Type of protection to EN 60079...

Depending upon the selected concept, the cable entry into the flameproof enclosure may be made:

- directly ( Ex- d cable entry or conduit) or
- in directly (Ex-e terminal box combined with Ex-d bushings).

Oil and liquids that can form explosive mixtures with air during decomposition must not, under any circumstances, be introduced into flameproof enclosure of the equipment. The restrictions specified in the standard shall be observed when installing batteries and cells.

Group II C equipment may also be operated in areas for groups II B and II A, and group II B equipment in areas for Group II A. The temperature class of apparatus indicates the permitted limiting temperature up to which the outer surfaces of such apparatus may rise.

### Examples for flameproof enclosures “d”

- Motors with slip rings and commutators
- Three-phase squirrel cage motors
- Switchgear with N/O and N/C contacts such as motor protection switches, circuit breakers, air-break contactors
- Control units, plugs and sockets
- Luminaires



Ex-d-pendant light fitting with indirect entry by an Ex-e terminal compartment



Ex-d-pendant light fitting with direct entry into the flameproof enclosure

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-2

#### Explosive atmospheres Part 2: Equipment protection by means of pressurization „p“

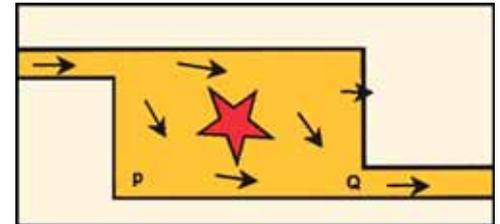
##### Definition:

Technique that prevents the ingress of the external atmosphere into an enclosure by maintaining a protective gas therein at a pressure above that of the external atmosphere.

Protection by pressurization is subdivided into three types of protection (px, py and pz) which are selected based upon the equipment protection level required for the external explosive gas atmosphere (Mb, Gb or Gc), whether there is the potential for an internal release, and whether the equipment within the pressurized enclosure is ignition-capable.

The overpressure of at least 50 Pa for px and py and 25 Pa for pz can either be maintained by a continuous purging with protective gas or by compensation of leakage losses only.

As a rule, air is used as the protective gas. The inert gas shall enter into or exit the enclosure outside of the hazardous area. The enclosure and all its ducts shall be purged prior to operation by a volume of gas that equals five times volume of the enclosure. The maintenance of the overpressure shall be monitored during operation and, if the overpressure drops, a warning signal shall be given or the equipment shall be switched off.



Principle of the type of protection “pressurization”

##### Examples for pressurization “p”:

- Electrical machinery with higher rating
- Control panels and switch cabinets
- Switch rooms
- Measuring and analyzing instruments
- Special machinery and equipment



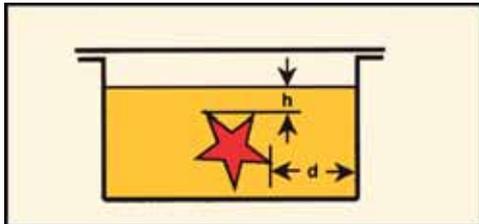
Terminal in pressurized, stainless steel enclosure

Flammable substances in the containment system	Requirements for the protection level of equipment for external explosive atmospheres	Enclosure contains ignition-capable equipment	Enclosure contains no ignition-capable equipment
No containment system	Gb or Mb	Type px <sup>a)</sup>	Type py
No containment system	Gc	Type pz	No pressurization required
Gas/vapour	Gb or Mb	Type px <sup>a)</sup>	Type py
Gas/vapour	Gc	Type px (and the ignition-capable equipment is not in the dilution range)	Type py <sup>b)</sup>
Liquid	Gb	Type px (inert) <sup>c)</sup>	Type py
Liquid	Gc	Type pz (inert) <sup>c)</sup>	No pressurization required <sup>d)</sup>

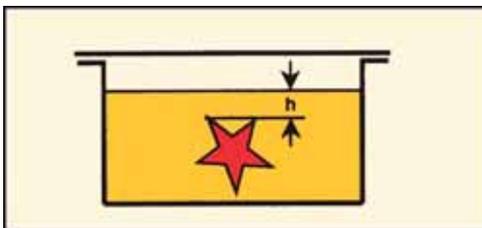
**NOTE:** If the flammable substance concerned is a liquid, it must never be released during normal operation.

- a) The type of protection px also applies for Group I.
- b) If there is no release during normal operation.
- c) The protective gas shall be inert, if the word “inert” is stated after the type of protection.
- d) No ignition protection by pressurization is required, as the simultaneous occurrence of a fault causing the release of liquids with a fault that can form an ignition source is considered to be improbable.

## Type of protection to EN 60079...



Principle of the type of protection "sand filling"



Principle of the type of protection "oil immersion"

### EN 60079-5

#### Explosive atmospheres Part 5: Equipment protection by means of sand filling „q“

##### Definition:

Type of protection where the parts of the equipment that could ignite an explosive gas atmosphere are secured in position and completely embedded in a filler to prevent the ignition, of the explosive gas atmosphere surrounding the enclosure. In addition to this, neither an ignition caused by flames nor an ignition as a result of increased temperatures on the enclosure surface should be possible.

With this type of protection, the enclosure is generally filled with glass beads or quartz sand, that have to meet specific requirements with regard to the grain size, purity, moisture content and disruptive strength. The stability of the enclosure shall be verified by means of a static pressure test. Enclosures of electrical equipment protected by the type of protection "q" shall be filled, closed and sealed during production. It shall not be possible for it to be opened without leaving visible signs. Electrical equipment where repairing is possible shall be fitted with suitable fasteners that can be opened without damaging the enclosure. After completion of repair work, the equipment shall be resealed and appropriately marked.

The built-in electrical components shall be adequately insulated, irrespective of the insulating effect of the filling material. In the case of bare, live parts, there must be sufficient space between the parts themselves and between the parts and the enclosure wall. The filling material is compressed, whereby, depending on the built-in components and requirements, the layers of filling material must have a specified thickness.

##### Examples for sand filling "q":

- Capacitors
- Small transformers
- Electronic equipment

### EN 60079-6

#### Explosive atmospheres - Part 6: Equipment protection by means of oil immersion „o“

##### Definition:

Type of protection where electrical equipment or parts of electrical equipment are immersed in a protective liquid in such a way that the explosive gas atmosphere above the liquid or outside the enclosure cannot be ignited.

With this type of protection, the ignition source is so deeply immersed in an oil-filled enclosure that a transmission of the flame to the area above the surface of the oil is prevented. This requires that the thermal output fed to the oil, the thermal energy and the resulting energy density be taken into account. In addition to ensuring that the oil level is sufficient in all operating positions of the equipment, the use of a suitable type of oil is important. The oil shall not decompose under influence of, for example, switching arcs. Moreover, by means of adequate dimensioning, among other things the dimensions of the oil filling, it shall be ensured that the equipment does not exceed the permitted temperature. The long term quality of the oil shall also be monitored, because the properties of the oil change due, for example, to sooting.

In the past, equipment in the type of protection Oil Immersion was widely used in the chemical industry for the local switching of motors. Due to the transition to remote switching and the increase in the number of interlocks, they have become increasingly insignificant and today oil-immersed switches are only used in exceptional cases. However, in the future, oil immersion could become increasingly important due to the use of high-power electronics in hazardous areas. Here the oil would fulfil two functions, as an ignition protection medium and cooling agent.

##### Examples for oil immersion „o“:

- Switchgear
- Transformers
- Electronics

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-7

#### Explosive atmospheres - Part 7: Equipment protection by means of Increased Safety "e"

##### Definition:

A type of protection applied to electrical apparatus where additional measures are applied 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.

##### Electrical connections

Depending on the respective requirements, for convenience, the electrical connections are sub-divided into those for field-wiring and those for factory wiring and into permanent types and re-connectable / re-wirable types. Each type shall, as applicable:

- a) be constructed in such a way that the conductors cannot slip out from their intended location during tightening of a screw or after insertion
- b) provide a means to avoid loosening of the connection in service
- c) be such that contact is assured without damage to the conductors such that would impair the ability of the conductors to fulfil their function, even if multi-stranded conductors are used in connections intended for direct clamping of a single conductor
- d) provide a positive compression force to assure contact pressure in service
- e) be constructed in such a way that the contact they assure is not appreciably impaired by temperature changes occurring in normal service
- f) except as permitted by the earth continuity test of IEC 60079-0, provide contact pressure that is not applied through insulating materials
- g) not be specified to accommodate more than one individual conductor in a clamping point unless specifically designed and assessed for doing so

- h) if intended for stranded conductors, employ a means to protect the conductors and distribute the contact pressure evenly.

##### Clearances and creepage distances

Compared to the distances required for industrial equipment according to EN 60664 for use in outside areas, to maintain an "increased safety" and exclude flashovers and the formation of creepage distances, the clearances and creepage distances have been increased considerably. (Initially by a factor of 1.5)

##### IP degree of protection

Enclosures containing bare conductive live parts shall provide at least the degree of protection IP54. For enclosures containing only insulated conductive live parts, the degree of protection IP44 is sufficient. If rotating electrical machines are installed in clean environments and are operated and regularly supervised by trained personnel, the degree of protection IP20 is sufficient for Group II. The restricted scope of application is stated on the machinery.

##### Surface temperatures

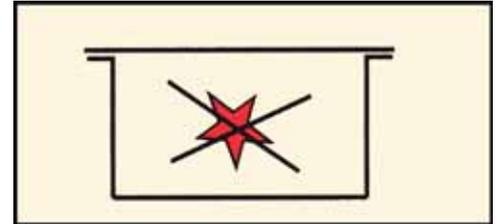
With this type of protection, the ingress of an explosive gas atmosphere is not excluded. For this reason, the permissible surface temperatures also apply for all surfaces inside an enclosure.

##### Mechanical strength

During the type test, all enclosures are subjected to an impact test that, in the case of plastics, also requires climatic conditioning (see also EN 60079-0). Supplementary requirements apply, in particular, for electrical machines, luminaires, batteries and terminal boxes.

##### Electrical machines:

All insulating materials are subject to natural ageing. In order to prolong the service life of the insulating materials of windings, compared to the windings in standard apparatus, the limiting temperature is lowered. This reduces the danger of damage to the windings and, as a result, the occurrence of arcs and sparks due to earth leakages or inter-winding faults.

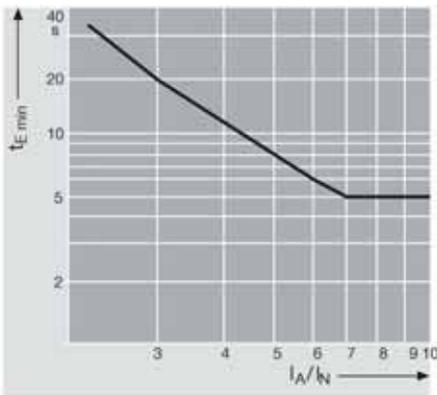


Principle of the type of protection "increased safety"

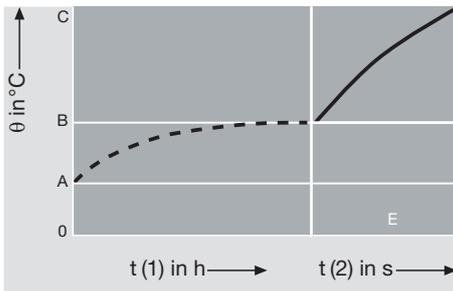


Explosion-protected fluorescent light fitting in the type of protection Ex-e

## Type of protection to EN 60079...

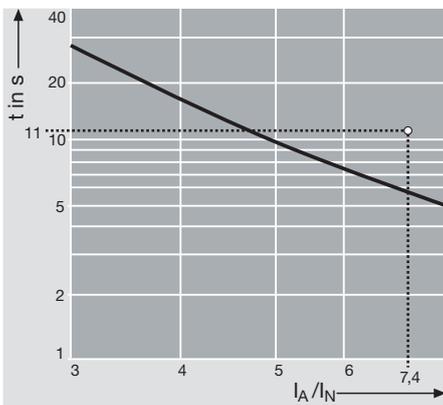


Minimum values for time tE



Calculation of time tE

- A max. permissible ambient temperature
- B temperature during rated operation
- C limit temperature
- t time
- θ temperature
- 1 heat rise during rated operation
- 2 heat rise with stalled motor



Tripping characteristic of thermal relay from cold state.

- time tE of motor to be protected 11 s
- IA/IN of motor to be protected 7.4

To protect the winding and to ensure adherence to the maximum permissible surface temperature, motors are normally used with overcurrent protection devices that respond in the event of difficult starting conditions or a malfunction. The purpose of these protective devices is to ensure that, having reached the continuous operation temperature after being in operation at rated output for several hours, a motor is still switched off safely before reaching the permissible limiting temperature if the rotor stalls due to a malfunction and, as a result, the motor draws an increased current.

If the rotor and the stator take different times to heat up, the shorter time will be taken as the disconnecting time. The time tE and the ratio of the starting current IA to rated current IN are stated on the type label and in the certificate of approval of the motor. The protection devices shall keep the specified tripping times within a tolerance of +/-20 %.

The adjacent tripping shows the characteristic curve of a thermal relay with an example for checking. The relay, which is set at the rated current of the motor, triggers at 7.4 times the rated current within a time that is shorter than the time tE, thus the relay is suitable for protecting the motor. The protection devices shall also switch off the motor in the event of the failure of an external conductor. Here, current-dependent, thermal overcurrent relays or circuit breakers that have to feature a phase failure protection can be used.

In general, electrical motors in the type of protection "increased safety" may only be used in continuous operation and for normal, seldom recurring starts to prevent the rises in temperature occurring during the start from exceeding the permissible limiting temperatures.

In the case of motors in the low-voltage range, thermal motor protection has the advantage that, due to the temperature gauges with positive temperature coefficient embedded in the windings, the rise in temperature during the start-up period in switching operation is monitored.

### Luminaires:

With the type of protection "e", the light source shall be one of the following:

- fluorescent lamps of the cold starting type with single-pin caps (Fa6) in accordance with IEC 60061-1
- tubular fluorescent bi-pin lamps with G5 or G13 lamp caps according to IEC 61195. These lamps shall be connected to circuits without pre-heating
- tungsten filament lamps for general lighting service in accordance with IEC 60064 and IEC 60432-1.

The lamps of all luminaires shall be fitted with a protective cover of adequate strength.

Lamp holders shall satisfy the requirements of the type of protection Flameproof Enclosure "d" or Increased Safety "e", whereby, with the latter type, they shall not be live during the replacement of lamps.

In addition, when using lampholders for bi-pin lamps, the following requirements apply:

- Maximum permissible ambient temperature +60 °C
- When using electronic ballasts, the temperature classes T6 and T5 are not permitted.
- Consideration of the EOL effect
- Forced opening of contacts to IEC 60947

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### Batteries and cell types

Only those cell types explicitly stated in the standard may be used. Charging and discharging devices shall be suitable for the type of cell being used and have to be certified. In particular, devices for protection against deep discharges and polarity-reversed charging shall be available.

When being transported in the hazardous area, the live parts of a battery shall be protected to at least IP30.

### Junction and connection boxes:

To ensure adherence to the limiting temperatures during operation, ratings shall be specified for junction and connection boxes.

This is, for example, based on the determination of the load data in relation to the terminal cross section (wire cross section) and the number of connected wires.

### Examples for increased safety "e":

- Three-phase cage rotors
- Transformers
- Current and voltage transformers
- Measuring instruments
- Luminaires
- Junction and connection boxes
- Terminal compartments for all electrical equipment



Explosion-protected emergency light fitting with self-contained battery system

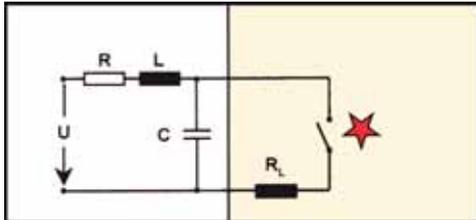


Light fitting for rod-shaped, bi-pin fluorescent lamps in the type of protection Ex-e for the illumination of a pump station. Three-phase Ex-e squirrel-cage motors as pump drives with plug-in connections (Ex-d/Ex-e).



Ex-e stainless steel terminal box

## Type of protection to EN 60079...



Principle of the type of protection "intrinsic safety"



Intrinsically safe modules for mounting on DIN rails

### EN 60079-11

#### Explosive atmospheres - Part 11 Equipment protection by intrinsic safety "i"

One of the more recent types of protection against explosion hazards by electrical apparatus and installations is called "intrinsic safety". The most common types of protection were conceived for electrical power engineering applications. As a result of increasing automation in hazardous areas, there has been an ever growing demand for explosion-protected measurement and control devices.

Intrinsically safe circuits only have a low energy content that is normally not sufficient to ignite an explosive mixture. Thus, for these circuits, the creation of a type of protection that makes use of this physical principle is the obvious solution.

#### Definitions:

##### Intrinsic safety "i"

A type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level below that which can cause ignition by either sparking or heating effects.

##### Intrinsically safe circuit

A circuit in which any spark or any thermal effect produced in the conditions specified in this standard, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive atmosphere.

##### Intrinsically safe apparatus

Electrical apparatus in which all the circuits are intrinsically safe circuits.

#### NOTE:

Distinction is made between the following types of intrinsically safe apparatus:

- Active intrinsically safe apparatus
- Passive intrinsically safe apparatus without stored energy
- Passive intrinsically safe apparatus with stored energy

#### Associated electrical apparatus

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

#### NOTE:

Associated apparatus may be either:

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

#### Safety barriers with diodes

Assemblies incorporating shunt diodes or diode chains (including Zener diodes) protected by fuses or resistors or a combination of both, manufactured as an individual apparatus rather than as part of a larger apparatus.



Intrinsically safe signal conditioning: field bus components in stainless steel enclosure

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### Apparatus for intrinsically safe circuits

As a basic principle, in the same way as for all other types of protection, the associated electrical apparatus used in an intrinsically safe circuit and the intrinsically safe apparatus have to be tested and certified. According to EN 60079, only apparatus where, according to the details given by the manufacturer, none of the values exceed 1.2 V; 0, 1 A; 20  $\mu$ F or 25 mW are exempted.

Simple intrinsically safe apparatus, where the electrical data and the thermal behaviour can be clearly defined and that conform to the applicable constructional requirements, do not need to be tested or certified. This applies, for example, to:

- switches
- plugs and sockets
- terminal boxes
- measuring resistors
- individual semi-conductor components
- coils (moving coil instruments)
- capacitors
- electric position sensors (DIN 19 234)

However, the general requirements according to EN 60079-0 and the design of enclosures and connection boxes with regard to the surface resistance or the choice of aluminium alloy (surface resistance of plastic enclosures  $<10^9$  Ohm) shall also be observed here.

### Limiting ignition curves

The energy set free in an intrinsically safe circuit in the event of a failure must be limited to such a degree that the occurrence of an ignition is prevented. To facilitate matters, the limiting ignition curves for the individual groups were established with the aid of a standardized spark test apparatus.

As the probability of the ignition of a mixture also depends on the number of switching operations, according to EN 60079-11 at least 1000 switching operations shall be performed, whereby an ignition must not occur under any circumstances.

Depending on the design of the intrinsically safe circuit, the existence of stored energy has to be taken into account. If there are capacitances in the intrinsically safe circuit, these are added on to the voltage of the circuit. In the event of a short circuit, in addition to the energy supplied by the associated apparatus the energy stored in the capacitor is released. The same applies if there are inductances in the circuit. For these reasons all three borderline cases, i. e. ohmic, capacitive and inductive circuits have to be taken into consideration.

### Level of protection

Intrinsically safe apparatus and intrinsically safe parts of associated electrical apparatus are allocated to a level of protection "ia", "ib" or "ic".

### Level of protection "ia"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ia" shall not be capable of causing ignition in any of the following circumstances:

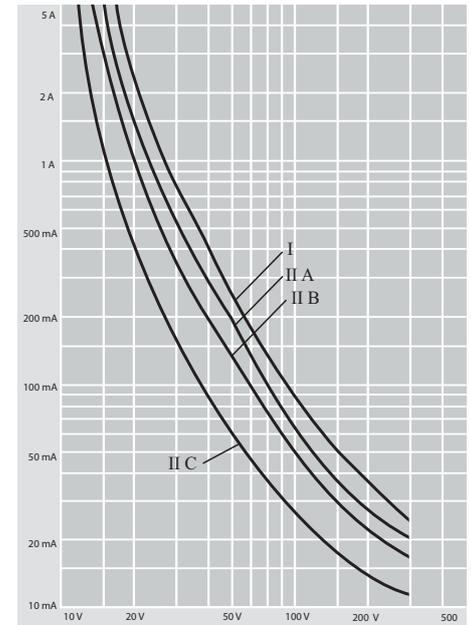
- a) in normal operation and with the application of those non-countable faults which give the most onerous condition;
- b) in normal operation and with the application of one countable fault plus those non-countable faults which give the most onerous condition;
- c) in normal operation and with the application of two countable faults plus those uncountable faults which give the most onerous condition.

The non-countable faults applied may differ in each of the above circumstances.

In testing or assessing the circuits for spark ignition, the following safety factors shall be applied

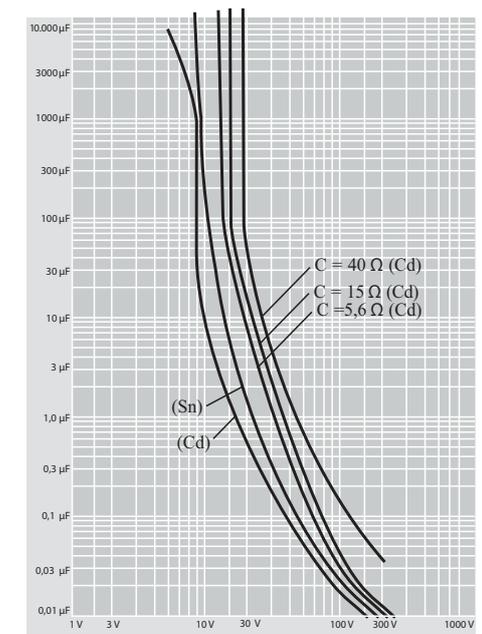
1.5 for both a) and b) and 1.0 for c).

The safety factor applied to voltage or current for the determination of the temperature class in accordance with the surface temperature shall be 1.0 in all cases.



### Ohmic circuits

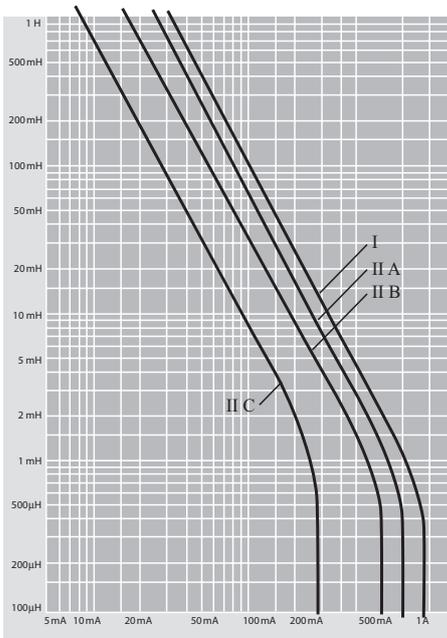
Minimum ignition current to be applied for electrical apparatus containing cadmium, zinc, magnesium or aluminium



### Capacitive circuits

Minimum ignition voltages to be applied to group IIC electrical apparatus. The curve marked Sn is only to be applied to electrical apparatus not containing any cadmium, zinc, magnesium or aluminium

## Type of protection to EN 60079...



### Inductive circuit

Minimum ignition current to be applied for electrical apparatus containing cadmium, zinc, magnesium or aluminium at  $U = 24 \text{ V}$ .

If only one countable fault can occur, the requirements of b) are sufficient for the level of protection "ia" if the test requirements for "ia" can then be satisfied. If no countable faults can occur, the requirements of a) shall be considered to give a level of protection of "ia" if the test requirements for "ia" can then be satisfied.

### Level of protection "ib"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ib" shall not be capable of causing ignition in any of the following circumstances:

- in normal operation and with the application of those non-countable faults which give the most onerous condition;
- in normal operation and with the application of one countable fault plus the application of those non-countable faults which give the most onerous condition.

The non-countable faults applied may differ in each of the above circumstances. When testing or assessing the circuits for spark ignition, a safety factor of 1,5 shall be applied. The safety factor applied to the voltage or current for the determination of surface temperature classification shall be 1.0 in all cases.

If no countable fault can occur the requirements of a) shall be considered to give a level of protection of "ib" if the test requirements for "ib" can then be satisfied.

### Level of protection "ic"

With  $U_m$  and  $U_i$  applied, the intrinsically safe circuits in electrical apparatus of level of protection "ic" shall not be capable of causing ignition in normal operation.

In testing or assessing the circuits for spark ignition, a safety factor of 1.0 shall be applied. The safety factor applied to the voltage or current for the determination of surface temperature classification shall be 1.0 in all cases.

### NOTE:

The concept of countable faults does not apply to this level of protection.

### Apparatus with galvanic isolation

Transformers that, for example, are built into intrinsically safe power supplies shall ensure a safe galvanic isolation between the primary and the secondary circuit.

The data that is relevant for the intrinsically safe circuit is determined by the output characteristic of this transformer and, if available, of any external circuits (voltage limitation by diodes, current limitation by resistors or by the electronics).

### Isolation of intrinsically safe circuits from non-intrinsically safe circuits

In order to avoid any mistakes when connecting or bridging conductors, the terminations of the intrinsically safe circuits shall be safely isolated from the terminations of a non-intrinsically safe circuit.

For this purpose, the terminals of the intrinsically safe circuit can, for example, be installed at a distance of at least 50 mm from the terminals of each non-intrinsically safe circuit or they can be separated by an isolating partition wall or an earthed metal partition wall. These partition walls shall either reach up to 1.5mm from the enclosure wall or they shall ensure a minimum clearance of 50 mm between the connection terminals.

### Isolation of insulated leads of intrinsically safe circuits and non-intrinsically safe circuits

The distance between the conductors of insulated cables shall satisfy the given requirements. With the exception of varnishes and similar coatings, this insulation is considered to be a solid insulation.

The clearances are determined by the addition of the radial thickness of the insulation on the wires. The minimum clearances are laid down in EN 60079-11:

- e.g.
- |                            |        |
|----------------------------|--------|
| for $U \leq 60 \text{ V}$  | 0.5 mm |
| for $U \leq 750 \text{ V}$ | 1.4 mm |

# Principles of Explosion-Protection

## Type of protection to EN 60079...

The voltage  $U$  is the sum of the voltages of the intrinsically safe circuits or of the intrinsically safe and non-intrinsically safe circuits. This clearance is not required, if:

- the cores of either the intrinsically safe or the non-intrinsically safe circuit are enclosed in an earthed screen, or
- in level of protection "ib" electrical apparatus, the insulation of the intrinsically safe cores is capable of withstanding an r.m.s. a.c. test voltage of 2000 V

Moreover, it is necessary to ensure that no inductive or capacitive interferences from the non-intrinsically safe circuit can occur in the intrinsically safe circuit.

### Planning of intrinsically safe circuits

When setting up an intrinsically safe circuit with just one intrinsically safe apparatus and one associated apparatus, the limiting values for the permissible external capacitance and the permissible external inductance shall be taken from the type label of the associated apparatus. They are decisive for the circuit. Then, based on the maximum possible power supply of the associated apparatus, it is only necessary to check the heat rise behaviour of the intrinsically safe apparatus. However, when several intrinsically safe circuits are interconnected (e.g. several pieces of associated apparatus for one intrinsically safe apparatus), a further verification of the intrinsic safety is necessary. The verification of the intrinsic safety of a circuit shall be documented in detail.

### Intrinsically safe circuits with Zener barriers

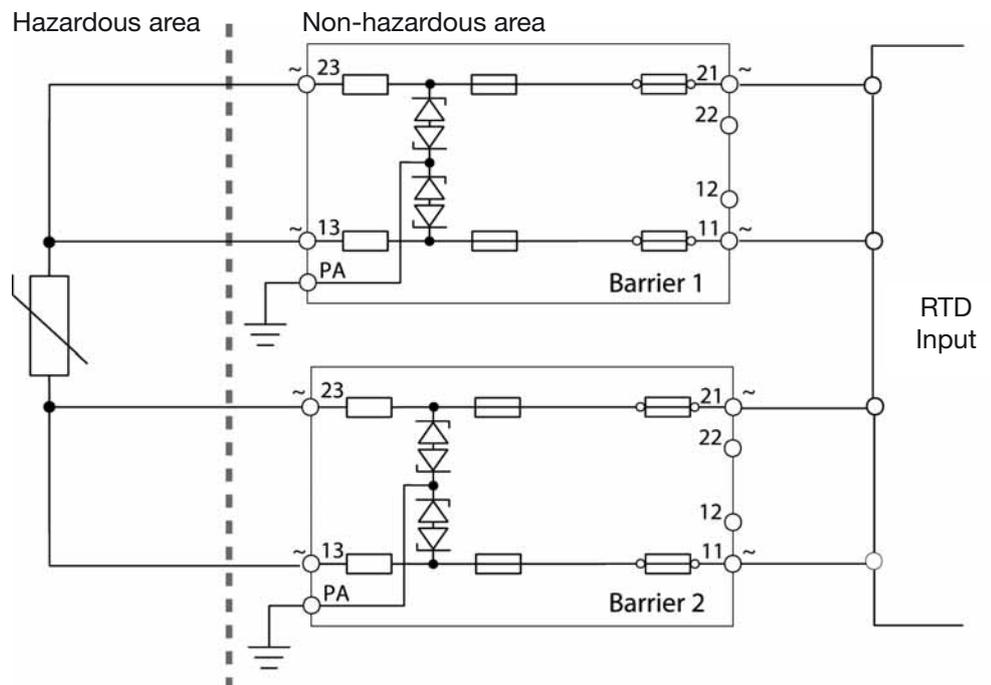
Normally intrinsically safe circuits shall be insulated. They may be earthed if this is required for functional reasons. They must, however, be earthed if this is mandatory for safety reasons. The earth connection may only be made at one point by connection with the potential equalization, which has to be available throughout the area in which the intrinsically safe circuit is installed. As, in the case of safety barriers, there is no galvanic isolation of the intrinsically safe circuit from the non-intrinsically safe circuit, for safety reasons there has to be a faultless earth connection.

### Working on and testing of intrinsically safe circuits

On principle, working on live intrinsically safe circuits is allowed, as, due to their design, no ignition can take place. However, the generally valid requirements for work on live parts shall be observed. When using measuring instruments, it is necessary to bear in mind that they might contain an internal energy store (e.g. the inductance of a moving coil indicator), that could nullify the intrinsic safety.

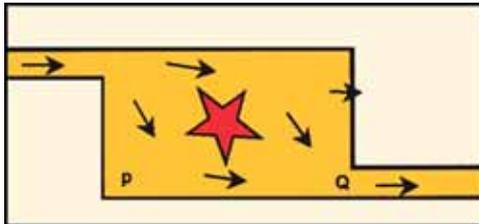
### Reduced separation distances

Under certain conditions specified in the standard, it is possible to design printed circuit boards with separation distances that are smaller than the standard distances that normally apply, thus enabling the use of smaller, more effective electronic elements.



Examples of an intrinsically safe application: 4-wire PT 100

## Type of protection to IEC 60079...



Principle of the type of protection "pressurization"

### EN 60079-13

#### Explosive atmospheres Part 13 Equipment protection by pressurized rooms "p"

This standard contains the requirements for the design, construction, testing, marking and maintenance of rooms for use in a potentially explosive atmosphere, whereby in these rooms:

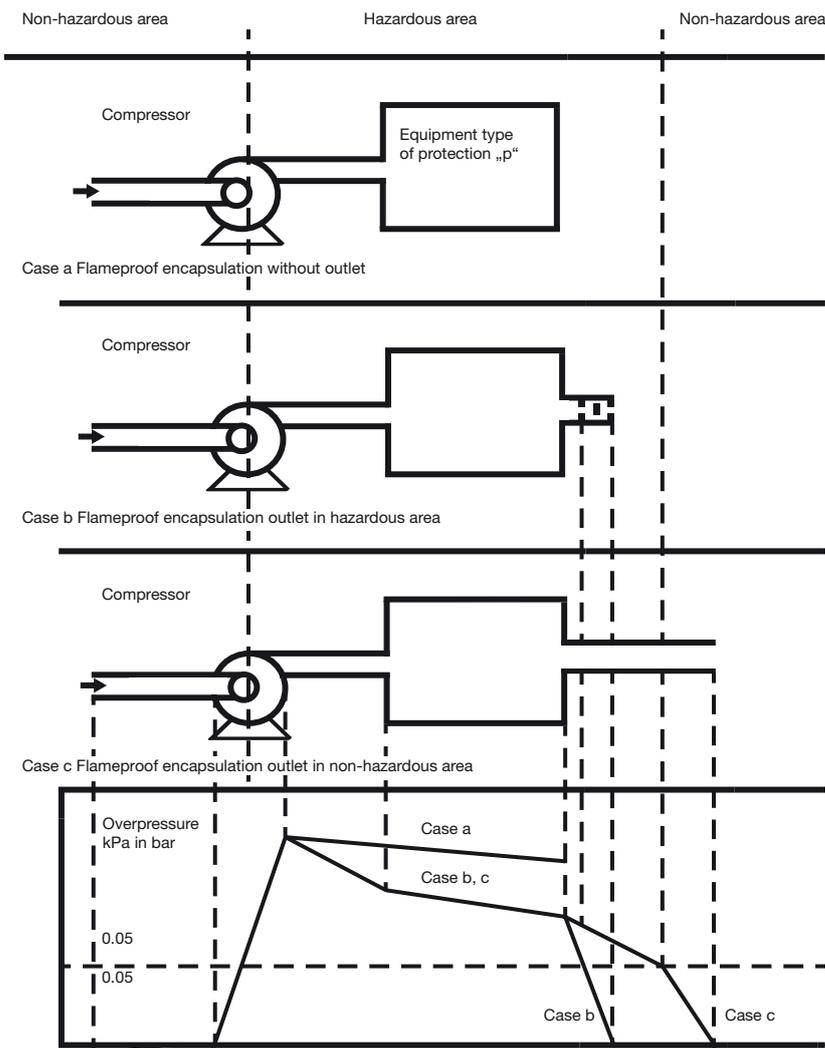
- a) pure air, that is maintained at a pressure above that of the surrounding atmosphere, is used to prevent the formation of an explosive atmosphere inside rooms with no internal source of release of flammable substances and, if necessary,
- b) an adequate quantity of pure air is supplied to ensure that the gas concentration of the mixture then present in the area surrounding electrical components is maintained at a value outside the explosion limits in accordance with the specific operating conditions. The pure air is supplied to a room or building with one or more internal sources of release of flammable substances to prevent the formation of an explosive atmosphere.

c) inert protective gas is fed into a room with specified safety devices to prevent the formation of an explosive atmosphere from one or more internal sources of release of flammable substances.

d) an adequate quantity of pure air is supplied to reduce personal damages caused by the release of toxic substances from one or more sources of release of these substances.

This standard contains requirements relating to the room and any associated installations, including pipelines for inlets and outlets as well as auxiliary devices for the safe generation and maintenance of the overpressure and/or dilution.

For the purposes of this standard, the term "room" relates to a single room, several rooms that are interconnected or a building.



Examples of static overpressure in pipelines and through a flameproof enclosure

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-15

#### Explosive atmospheres - Part 15 Equipment protection by type of protection „n“

#### Definitions:

##### Type of protection "n"

Type of protection applied to electrical equipment where, in normal operation and in certain specified regular expected occurrences, it is not capable of igniting a surrounding explosive gas.

##### NOTE:

Furthermore, the requirements of this standard are intended to ensure that a malfunction capable of causing ignition is not likely to occur.

##### Non-sparking device "nA"

A device constructed to minimize the risk of the occurrence of arcs or sparks capable of creating an ignition hazard during conditions of normal operation.

##### NOTE:

For the purposes of this standard, normal operation is considered to exclude the removal or insertion of components while the circuit is energized.

##### Enclosed break device "nC"

A device incorporating electrical contacts that are made and broken and that will withstand an internal explosion of the flammable gas or vapour which may enter it without suffering damage and without communicating the internal explosion to the external flammable gas or vapour.

##### NOTE:

The principle difference between enclosed break devices "nC" and flameproof "d" are that the dimensions are not controlled and that safety factors have not been added.

Type of protection	Type of protection „n“ for electrical zone 2 / category 3G / EPL Gc-equipment			
IEC GENELEC	EN 60079-15			
Symbol	nA	nC	nR	nL
Definition	Non-sparking equipment	Equipment with protected contacts	Restricted breathing enclosure	Energy-limited equipment
Description of the protection method	Minimizes the risk of high surface temperatures or arcs and sparks inside. To be included as „ec“ in EN 60079-7 in the future.	Must withstand an explosion inside, or the outside Ex atmosphere must not be able to penetrate in. No ignition by simple „d“ encapsulation. To be included as „dc“ in EN 60079-1 in the future.	Enclosure designed that the penetration of Gas is limited.	Apparatus with simple intrinsically safe circuits and components. Now included as „ic“ in EN 60079-11

## Type of protection to EN 60079...



Electrical machines:  
Plug-in connection of pump drives,  
protection „nA“

### Hermetically-sealed device “nC”

A device which is so constructed that the external atmosphere cannot gain access to the interior and in which the seal is made by fusion, for example by soldering, brazing, welding or the fusion of glass to metal.

### Non-incendive component “nC”

A component with contacts for making or breaking a specified ignition capable circuit, but in which the contacting mechanism is designed and constructed in such a way that the component is not capable of causing ignition of a specified explosive gas atmosphere.

#### NOTE:

The enclosure of the non-incendive component is not intended to either exclude the explosive gas atmosphere or contain an explosion. This is usually applied to specially constructed switch contacts that are mechanically designed to quench any arc or spark so that they are not a source of ignition.

### Sealed device “nC”

A device which is constructed in such a way that it cannot be opened during normal service and is sealed effectively to prevent the ingress entry of an external atmosphere.

### Restricted-breathing enclosure “nR”

An enclosure that is designed to restrict the ingress of gases, vapours and mists.

In the meantime, the type of protection “nL”, which is still included in EN 60079-15, has been integrated as “ic” in EN 60079-11.

As a rule, the general requirements of EN 60079-0 are also decisive for equipment in the type of protection „n“.

### Supplementary requirements for equipment in the type of protection “nA”

With some equipment, e.g.

- Electrical machines
- Fuses
- Luminaires

The requirements have, however, been modified and adapted to the reduced requirements.

### Electrical machines

The requirements of this standard assume that the occurrence of an explosive gas atmosphere and a motor start sequence do not occur simultaneously, and may not be suitable in those cases where these two conditions do occur simultaneously. “Normal” operating conditions for electrical machines are assumed to be rated full-load steady conditions.

The starting (acceleration) of electrical machines is excluded as part of “normal” operation under duty S1 or S2. Due to the potential for more frequent starts of motors with duty S3 to S10, the requirements for rotor sparking address the risk of rotor sparking during starting as a “normal” condition.

### Fuses

Fuses shall be deemed non-sparking devices if they are non-rewirable, non-indicating cartridge types or indicating cartridge types, according to IEC 60269-3, operating within their rating.

#### NOTE:

The rupture of the fuse is not considered to be normal operation.

### Luminaires

The restrictions for luminaires included in the type of protection “e” relating to the types of luminants that can be used and the starting conditions do not apply in full for the type of protection “n”.

# Principles of Explosion-Protection

## Type of protection to EN 60079...

What is more, further special conditions are described in the standard, e.g.

### Supplementary requirements for non-sparking low power equipment

Further reductions have been specified with regard to clearances and creepage distances for electronic and allied low power equipment, assemblies and sub-assemblies with a rated voltage up to 275 V a.c. or 390 V d.c. with a rating of < 20 W, that are used, for example, for measurement, control or communication purposes.

### Supplementary requirements for restricted-breathing enclosures „nR“

Restricted breathing equipment shall generally be limited with regard to the dissipated power so that the temperature measured on the outside does not exceed the maximum surface temperature. Restricted breathing equipment containing normally arcing or sparking devices, or equipment with hot surfaces designed to have frequent temperature cycles, shall be limited in dissipated power so that the temperature measured on the outside of the enclosure does not exceed the external ambient temperature by more than 20 K.

Restricted breathing equipment with no devices that give off arcs or sparks - under normal conditions - but with hot surfaces in normal operation shall be limited with regard to the dissipated power, so that the temperature measured on the outside does not exceed the marked temperature class.

### Design

	Temp. limitation	Test report	Routine testing
Sparking	Ta + 20 K	Yes	required
Non sparking	T class	No	required
Non sparking	T class	Yes	Depending on type test

### Test procedure

Type test	Test report	Routine testing
0,3 kPA - 0,15 kPA/360 sec	Yes	No
0,3 kPA - 0,15 kPA/180 sec	No	0,3 kPA - 0,15 kPA/180 sec 0,3 kPA - 0,15 kPA/27 sec 0,3 kPA - 0,15 kPA/27 sec
0,3 kPA - 0,15 kPA/90 sec	Yes	0,3 kPA - 0,15 kPA/180 sec 0,3 kPA - 0,15 kPA/27 sec 0,3 kPA - 0,15 kPA/27 sec

Construction and test requirements of restricted breathing enclosures

## Type of protection to EN 60079...

### EN 60079-18

#### Explosive atmospheres - Part 18 Equipment protection by encapsulation „m“

##### Definition:

A 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 as to avoid the ignition of a dust layer or explosive atmosphere under operating or installation conditions.

The type of protection Encapsulation “m” can be used in all zones and in explosive gas and dust atmospheres. Depending upon the location of operation, they are subdivided into the EPLs Ga, Gb, Gc, Da, Db, Dc and Ma and Mb.

Thermosetting, thermoplastic, epoxy resin or elastomeric materials with or without fillers and/or additives may be used as potting compounds. The selection of the compound for a particular application is dependent on the purpose it is to fulfil in the equipment. The encapsulation shall ensure the effectiveness of the type of protection subject to the EPL, even in the event of admissible overloads and certain faults.

Voids in the compound for accommodating components such as relays, transistors, etc. are permitted up to a volume of 100cm<sup>3</sup>. Specially designed multilayer printed circuit boards are also regarded as being encapsulated.

##### Examples for encapsulation „m“:

- Relays, signalling and control gear
- Electronic equipment and components
- Small transformers
- Solenoid valves



Potted electrical components

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-25

#### Explosive atmospheres - Part 25 Intrinsically safe electrical systems

#### Definitions:

##### Intrinsically safe electrical system:

An assembly of interconnected items of electrical apparatus, 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 circuits.

##### Certified intrinsically safe electrical system:

An intrinsically safe electrical system for which a certificate has been issued confirming that the electrical systems complies with the standard.

##### Uncertified intrinsically safe electrical system:

An intrinsically safe electrical system for which the knowledge of the electrical parameters of the items of certified intrinsically safe electrical apparatus, certified associated apparatus, simple apparatus and the knowledge of the electrical and physical parameters of the interconnecting wiring permit the unambiguous deduction that the intrinsic safety is preserved.

##### Descriptive system document :

A document in which the individual electrical items of apparatus, their electrical parameters and the parameters of the interconnecting wiring are specified. Such a descriptive system document shall be created for all systems. It shall provide an adequate analysis of the level of protection achieved by the system.

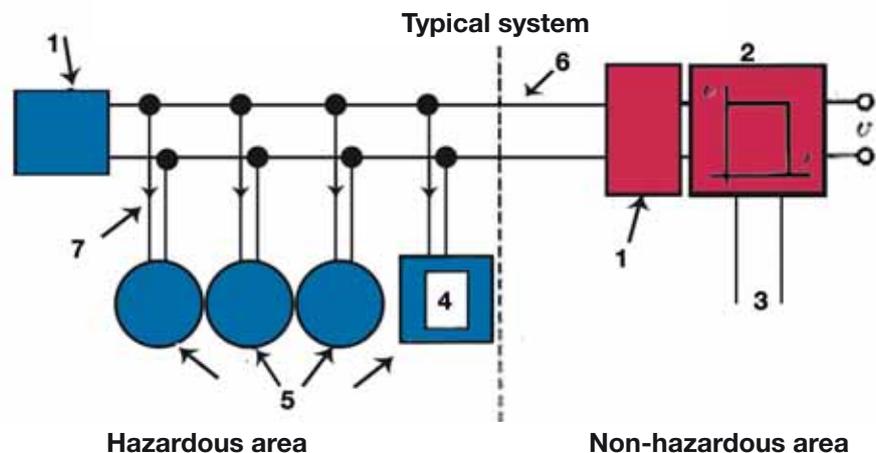
The minimum requirements are:

- a block diagram of the system listing all the items of apparatus within the system
- a statement of the group subdivision, the level of protection for each part of the system, the temperature classification and the ambient temperature rating of the system

- the requirements and permitted parameters of the interconnecting wiring
- details of the earthing and bonding points of the systems
- Where applicable, the justification of the assessment of apparatus as "simple apparatus" according to EN 60079-11 shall be included. In particular, where several types of simple apparatus are included, the analysis of the summation of their parameters shall be available. Their interaction shall be shown in a block diagram
- a unique identification of the descriptive system document shall be created
- The system designer shall sign and date the document.



Components for intrinsically safe electrical system



#### Legend

- 1 Terminating resistor
- 2 Supply unit
- 3 Data
- 4 Handheld controller

- 5 Field apparatus
- 6 Main line
- 7 Branch line

## Type of protection to EN 60079...

### EN 60079-26

#### Explosive atmospheres - Part 26 Equipment with equipment protection level (EPL) Ga

This standard lays down detailed requirements for equipment with equipment protection level (EPL) Ga (equipment group II, category 1G). The equipment shall be designed and constructed in such a way that it ensures a very high level of safety during normal operation. It is intended for use in hazardous areas where explosive mixtures of air with gases, vapours or mists occur continuously for long periods or frequently.

This standard also applies to equipment installed in the partition wall between areas with different degrees of hazard. It also contains requirements for equipment that is installed outside the hazardous area, but is electrically connected to equipment with the protection level Ga (associated apparatus). To eliminate any potential ignition hazards from electrical circuits of the equipment,

the requisite degree of safety shall either be ensured by the application of a single equipment means of protection, even in the event of the simultaneous occurrence of two independent malfunctions, or, in the event of the failure of one equipment means of protection, it shall be ensured by a second means of protection.

#### Individual equipment means of protection

The following individual equipment means of protection are permitted:

- equipment and circuits in accordance with the requirements of EN 60079-11, level of protection "ia"

and

- encapsulated equipment in accordance with the requirements of EN 60079-18 "ma".

#### Combinations of different protection methods

Electrical equipment shall comply with the requirements of the standards of the series EN 60079-0 and the following, independent of each other. These combined, standardized types of protection shall be based on different physical protection principles. They shall be verified independently.

#### Use of partition walls

The table shows the possible combinations of partition walls and types of protection. The equipment and parts thereof in Zone 0 shall be designed and constructed in such a way that

- ignition sources due to sparks caused by impact or friction are ruled out. If equipment contains moving parts, light metals must not be used at the possible points of friction or impact or other accessible points
- ignition hazards due to hazardous electrostatic charges cannot occur.

#### Connection

Connections for equipment and parts thereof in Zone 0 shall, wherever possible, be located outside Zone 0.

Type of construction	Requirements to the thickness $t$ of the barrier i) $t \geq 3$ mm: no additional measures		
	(ii) $3 \text{ mm} > t \geq 1 \text{ mm}$	(iii) $1 \text{ mm} > t \geq 0,2 \text{ mm}$ (X-symbol)	(iv) $t < 0,2 \text{ mm}$ (X-symbol)
<b>a) Barrier</b>			
	EPL Gb type of protection no ignitable sparks during operation (e.g. no open switching contacts)	Type of protection Intrinsic safety „ib“	Not permissible
<b>b) Barrier and gap</b>			
	EPL Gb type of protection	EPL Gb type of protection	EPL Gb type of protection no ignitable sparks during operation (e.g. no open switching contacts)
<b>c) Barrier and ventilation</b>			
	EPL Gb type of protection	EPL Gb type of protection and flameproof joint (broken line)	

<sup>a)</sup> Flameproof joint and barrier can be swapped round.

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-27

#### Explosive atmospheres - Part 27 Field bus intrinsically safe concept (FISCO)

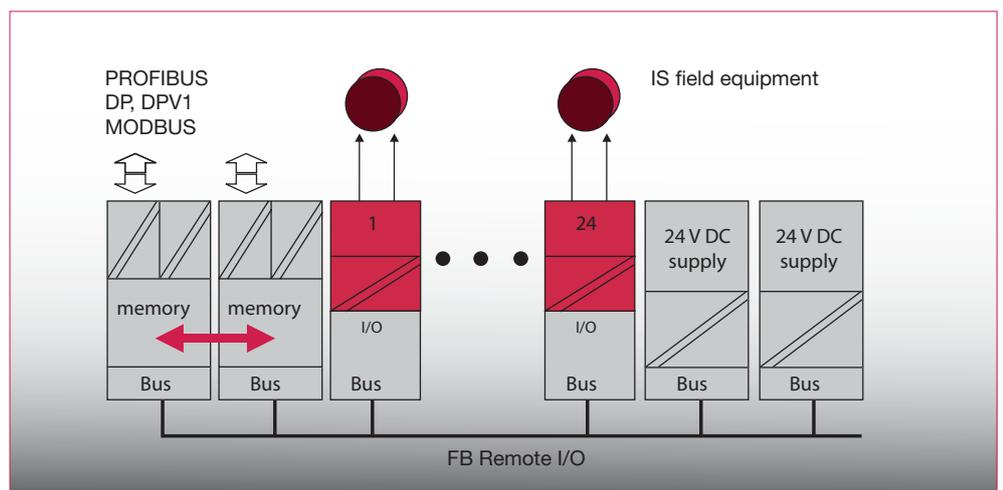
This standard contains the requirements for apparatus, systems and installation practices for use with the

*Field bus Intrinsically Safe Concept (FISCO).*

It is based on the concepts of Manchester encoded, bus powered systems designed in accordance with IEC 61158-2, which is the physical layer standard for field bus installations.

In the meantime, the constructional and installation requirements for FISCO apparatus and systems are laid down in EN 60079-11, EN 60079-14 and EN 60079-25, except as modified by this standard. Part of a field bus device may be protected by any of the methods of explosion-protection listed in IEC 60079-0, appropriate to the zone of intended use. In these circumstances, the requirements of this standard apply only to that part of the apparatus directly connected to the intrinsically safe trunk or branch lines.

Generally speaking, "ic" FISCO systems are intended for use in Zone 2 areas. FISCO systems are mainly intended for use in Zones 1 and 2, but they may lead into Zone 0 areas if this is explicitly permitted in the documentation.



## Type of protection to EN 60079...



Light emission from luminaire for use in zone 0. Light transmission via glass fibre cables. Light source in zone 1.

### EN 60079-28

#### Explosive atmospheres - Part 28 Protection of equipment and transmission systems using optical radiation

Optical equipment in the form of lamps, lasers, LEDs, optical fibres, etc. is increasingly used for communications, surveying, sensing and measurement. Often the installation is inside or close to potentially 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 surrounding explosive atmosphere.

There are four possible ignition mechanisms:

- a) Optical radiation is absorbed by surfaces or particles, causing them to heat up, and, under certain circumstances, this may allow them to attain a temperature which will ignite a surrounding explosive atmosphere
- b) Thermal ignition of a gas volume, where the optical wavelength matches an absorption band of the gas
- c) Photochemical ignition due to photo dissociation of oxygen molecules by radiation in the ultraviolet wavelength range

- d) Direct laser induced breakdown of the gas at the focus of a strong beam, producing plasma and a shock wave, whereby both could possibly act as the ignition source.

Three types of protection can be applied to prevent ignitions by optical radiation in potentially explosive atmospheres:

- a) inherently safe optical radiation, type of protection “op is”
- b) protected optical radiation, type of protection “op pr”
- c) optical system with interlock, type of protection “op sh”.

#### Inherently safe optical radiation type of protection “op is”

Inherently safe optical radiation means visible or infrared radiation that is incapable of supplying sufficient energy under normal or specified fault conditions to ignite a specific explosive atmosphere.

#### Protected optical radiation type of protection “op pr”;

This concept requires radiation confined inside optical fibre or other transmission medium based on the assumption that there is no escape of radiation from the confinement. In this case, the performance of the confinement defines the safety level of the system.

#### Optical radiation interlock with optical fibre breakage Type of protection “op sh”

This type of protection is applicable when the radiation is not inherently safe with interlock cut-off if the protection by the confinement fails and the radiation becomes unconfined on time scales suitably shorter than the ignition delay time.

Equipment group	I	IIA	IIB	IIC	IIC	IIC
Temperature class		T3	T4	T4	T4	T6
Temperature class (°C)	< 150	< 200	< 135	< 135	< 135	< 85
Power (mW)	150	150	35	35	35	15
Irradiance (mW/mm <sup>2</sup> ) (surface area not exceeding 400 mm <sup>2</sup> )	20*	20*	5	5	5	5
* For irradiated areas greater than 30 mm <sup>2</sup> where combustible materials may intercept the beam, the 5 mW/mm <sup>2</sup> irradiance limit applies.						

Safe optical power and irradiance for hazardous locations categorized by apparatus group and temperature class

# Principles of Explosion-Protection

## Type of protection to EN 60079...

### EN 60079-30-1

#### **Explosive atmospheres Part 30-1 Electrical resistance trace heating General and testing requirements**

This standard specifies the general and testing requirements for electrical resistance trace heaters for use in explosive gas atmospheres.

It encompasses trace heaters that may comprise either factory or field-assembled units, e.g. series or parallel heating cables, heating pads or heating panels that have been assembled and/or terminated in accordance with the manufacturer's instructions. The electrical resistance trace heating shall be designed and constructed in such a way that it can be operated safely in the hazardous area, whereby the components used shall comply with the relevant type of protection.

Furthermore, it is necessary to ensure that, under all circumstances and maintaining the safety clearance, the surface temperature of the resistance trace heating remains below the ignition temperature of the explosive mixture. If this cannot be ensured by the design of the heating cable, suitable safety thermostats shall be used as limiters.



Example of a trace heating system

## Type of protection to EN 60079...



Dust deposits in an industrial plant

### EN 60079-31

#### Explosive atmospheres - Part 31 Equipment dust ignition protection by enclosure "t"

##### Definition:

A type of protection for explosive dust atmospheres where electrical equipment is provided with an enclosure providing dust ingress protection and a means to limit surface temperatures.

This standard is applicable to electrical equipment protected by enclosure and surface temperature limitation for use in explosive dust atmospheres. It specifies requirements for design, construction and testing of electrical equipment. It contains the requirements for the three levels of protection "ta", "tb" and "tc", thus allowing the application of the EPLs Da, Db and Dc. It does not apply to dusts of explosives, which do not require atmospheric oxygen for combustion, or pyrophoric substances.

Furthermore, it does not apply to electrical equipment intended for use in underground parts of mines susceptible to firedamp. Nor does it take those parts of surface installations of such mines endangered by fire-damp and/or combustible dust into consideration.

##### NOTE:

The use of electrical equipment in atmospheres which may contain both combustible dust and explosive gases, whether simultaneously or separately, may require additional protective measures.

##### Pressure test

A perfect sealing function is of essential importance for the type of protection "t". For this reason, a pressure test is required before the IP test is carried out. This is to ensure that the seal is held safely in position in the event of the occurrence of internal overpressures a result of, for example, temperature fluctuations.

Additional requirements for equipment in the level of protection "ta"

- Limitation of the maximum permissible short-circuit current
- Version for testing IP6X with enhanced requirements
- Thermal test on enclosures where all available surfaces are surrounded by dust with a layer thickness of at least 500 mm
- Limitation of the temperature of built-in parts and components



Dust ignition protection by enclosure „t“:  
Fluorescent light fitting inside an explosive dust atmosphere

# Principles of Explosion-Protection

## Types of protection to EN 61241...

### EN 61241-4

**Electrical equipment for use in the presence of combustible dust – Part 4**  
**Type of protection “pD”**

**Definition:**

**Definition:**

Method using a protective gas in a housing to prevent the formation of an explosive dust atmosphere by maintaining an internal overpressure compared to the surrounding atmosphere. This standard gives requirements on the design, construction, testing and marking of electrical apparatus for use in combustible dust atmospheres in which a protective gas (air or inert gas), which is maintained at a pressure above that of the external atmosphere, is used to prevent the entry of dust which might otherwise lead to the formation of a combustible mixture in enclosures which do not contain a source of combustible dust. It contains the specific requirements for construction and testing, including protective requirements that apply to electrical apparatus with type of protection pressurization “pD”. Requirements for pressurized enclosures with an internal source of dust release are not included in this standard. The overpressure of at least 50 Pa can be maintained by constant purging with an inert gas or by the compensation of any leakage losses only. As a rule, the protective gas used is air. The inert gas shall enter into or exit the enclosure outside of the hazardous area. To ensure that any dust accumulations have been removed, the enclosure shall be cleaned prior to operation. The maintenance of the overpressure shall be monitored during operation and, if the overpressure drops, a warning signal shall be given or the equipment shall be switched off.

**Examples for pressurization “pD”:**

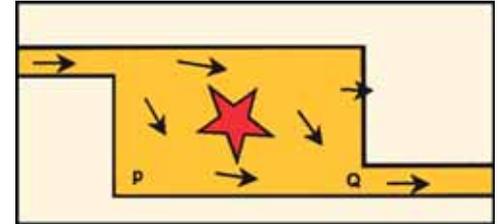
- Electrical machines with higher output
- Switch panels and cabinets
- Central control rooms

The integration of the contents of this standard in the standard EN 60079-2 is planned.

### EN 61241-11

**Electrical equipment for use in the presence of combustible dust – Part 11**  
**Type of protection “iD”**  
**protection by intrinsic safety**

The contents of this standard have already been integrated in EN 60079-11.

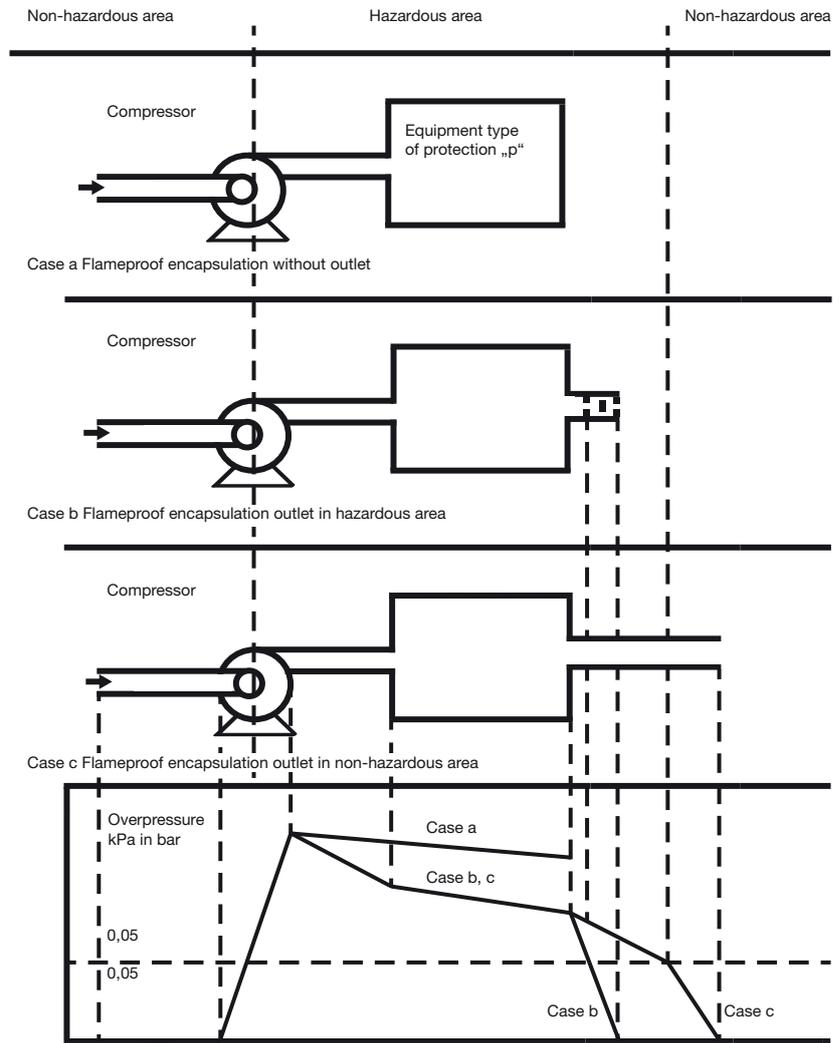


Principle of the type of protection “pressurization”

### EN 61241-18

**Electrical equipment for use in the presence of combustible dust – Part 18**  
**Type of protection “mD”**  
**protection by encapsulation**

The contents of this standard have already been integrated in EN 60079-18.



Examples of static overpressure in pipelines and through a flameproof enclosure

## Explosion-protection of mechanical equipment



### Explosion-protection of mechanical equipment

Unlike the first directive for equipment for use in potentially explosive atmospheres, which was restricted to electrical apparatus, Directive 94/9/EC now applies to all equipment. For this reason, analogue to those for electrical equipment, a series of standards encompassing the design and testing requirements for mechanical equipment was drawn up. The valid harmonized standards are listed in the "OJ" (Official Journal): *"Commission communication in the framework of the implementation of Directive 94/9/EC of the European Parliament and of the Council on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres"*

### Overview of the standards for mechanical equipment, currently included in the "OJ" (Official Journal)

These requirements are specified in the series of standards EN 13463.

### EN 13463-1:2001

#### Non-electrical equipment for use in potentially explosive atmospheres - Part 1: Basic method and requirements

This part specifies the general method for the risk assessment of mechanical equipment. It is based on the prevention of the formation of mechanical ignition sources. If this is not possible by applying constructional measures, measures are taken to prevent these ignition sources from becoming effective. In addition, measures are applied to prevent the concurrence of effective ignition sources with the explosive atmosphere. Another method is the enclosing of a possible explosion to prevent propagation to outer areas. The structure of the mechanical types of protection is based on these measures:

ESO	Reference and title of the harmonised standard Norm (and reference document)
CEN	EN 1010-1: 2004 + A1 2010 Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines - Part 1: Common requirements
CEN	EN 1010-2: 2006 + A1 2010 Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines - Part 2: Printing and varnishing machines including pre-press machinery
CEN	EN 1127-1: 2007 Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology
CEN	EN 13463-1: 2009 Non-electrical equipment for use in potentially explosive atmospheres - Part 1: Basic method and requirements
CEN	EN 13463-2: 2004 Non-electrical equipment for use in potentially explosive atmospheres - Part 2: Protection by flow restricting enclosure 'fr'
CEN	EN 13463-3: 2005 Non-electrical equipment for use in potentially explosive atmospheres - Part 3: Protection by flameproof enclosure 'd'
CEN	EN 13463-5: 2003 Non-electrical equipment intended for use in potentially explosive atmospheres - Part 5: Protection by constructional safety "c"
CEN	EN 13463-6: 2005 Non-electrical equipment for use in potentially explosive atmospheres - Part 6: Protection by control of ignition source 'b'
CEN	EN 13463-8: 2003 Non-electrical equipment for potentially explosive atmospheres - Part 8: Protection by liquid immersion 'k'

# Principles of Explosion-Protection

## Explosion-protection of mechanical equipment

### 1. Avoidance of the formation of ignition sources:

EN 13463-5:2003

#### Non-electrical equipment for use in potentially explosive atmospheres - Part 5: Protection by constructional safety "c"

The equipment is dimensioned and designed in such a way (e.g. special tightness and overdimensioning) that no ignition source can occur during the service life of the equipment, even in the event of expected faults. This type of protection is applied, for example, for bearings and couplings. The mechanical type of protection intrinsic safety "g" has been integrated in the general requirements and in the type of protection "c", so that work on the planned Part 4 was discontinued.

### 2. Ignition sources do not become effective:

EN 13463-6:2005

#### Non-electrical equipment for use in potentially explosive atmospheres - Part 6: Protection by control of ignition source 'b'

Many types of non-electrical equipment for use in hazardous areas do not contain an effective ignition source. However, there is a risk that an ignition source might occur in the event of the malfunction of the moving parts or of an abnormal operation.

To prevent potential ignition sources from becoming effective during normal operation, a malfunction or a rare malfunction, it is possible to incorporate sensors into the equipment to detect impending hazardous conditions and to initiate counter measures at an early stage before potential ignition sources can become effective. The measures applied can be initiated automatically via direct connections between the sensors and the ignition prevention system or manually by issuing a warning to the operator of the equipment (with the aim that the operator takes ignition prevention measures, e.g. by stopping the equipment).

### 3. Prevention of the coming together of effective ignition sources with the explosive:

EN 13463-8:2003

#### Non-electrical equipment for use in potentially explosive atmospheres - Part 8: Protection by liquid immersion "k"

Equipment in this type of protection feature potential ignition sources that are rendered ineffective by immersing them in a protective liquid or by continuously coating them with a film of protective liquid, e.g. disc brakes that are immersed in oil or oil-filled gear boxes where the gear wheels are partially immersed, but are continuously coated by a viscous oil film.

EN 13463-2:2004

#### Non electrical equipment for use in potentially explosive atmospheres - Part 2: Protection by flow restricting enclosure "fr"

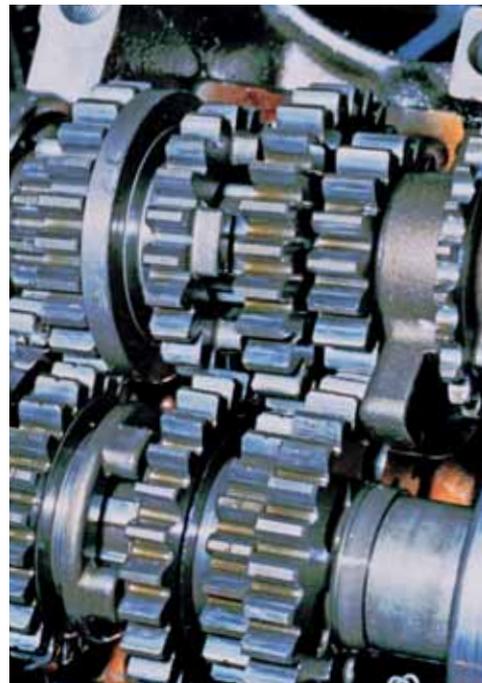
A flow-restricting encapsulation is applied for enclosures that, with a reasonable degree of probability, prevent the atmosphere inside the enclosure from becoming explosive if the atmosphere surrounding the enclosure is explosive on rare occasions and for a short time only. For this reason, the application of this standard is restricted to satisfying the requirements for equipment category 3.

### 4. Prevention of the propagation of a possible explosion to outer areas:

EN 13463-3:2005

#### Non electrical equipment for use in potentially explosive atmospheres - Part 3: Protection by flameproof enclosure "d"

The requirements for this type of protection are basically the same as those for electrical equipment. For this reason, to avoid repetition, this standard only outlines the differences to mechanical applications.



**EN 50495**

**Safety devices required for the safe functioning of equipment with respect to explosion risks**

**EN 50495**

**Safety devices required for the safe functioning of equipment with respect to explosion risks**

This standard determines the safety requirements for electrical devices, which are used to control the ignition hazards of equipment used in hazardous areas. This also includes safety devices which are operated outside hazardous areas to ensure the safe function of equipment or protective systems in order to control explosion hazards. Electrical equipment that is intended for use in explosive atmospheres is dependent on the correct functioning of the safety devices, for example, adherence to the given characteristics of the equipment within the permissible limits.

Examples of such protection devices are motor protection devices (e.g. to limit temperature rise during stall conditions) and control devices for the protection of the pressure compensation. Sources of ignition can be avoided by means of control or monitoring devices. Therefore these devices should execute the appropriate measures in the appropriate reaction time, for example the initiation of an alarm or an automatic shut down. Safety devices where the safety function cannot be adequately specified in accordance with the existing standards of the series EN 60079 or EN 61241 shall also comply with the requirements of this standard.

**Safety properties of the safety device**

A safety device shall afford the level of operational safety dependent on the reduction of the risk of an ignition source for the Equipment Under Control (EUC).

The adjacent table shows the requisite safety properties of a safety device if this is used for monitoring an Equipment Under Control (EUC) with a potential ignition source and an initial fault tolerance to attain the maximum equipment category for combined equipment.



Fault tolerance of EUC	2	1	0	1	0	0
<b>Safety device</b>						
Fault tolerance of hardware	-	0	1	-	0	-
Safety integrity level	-	SIL 1	SIL 2	-	SIL 1	-
<b>Combined apparatus</b>						
Group I	Category	M1		M2		-
Groups II,III	Category	1		2		3

**Note:**  
 Fault tolerance::  
 "0" indicates that the EUC performs a source of ignition in normal mode of operation. One single fault may cause the safety device to fail.  
 "1" indicates that the equipment is safe if one fault occurs. Two independent faults may cause the equipment to fail.  
 "2" indicates that the equipment is safe in the event of two independent faults. Three faults may cause the equipment to fail.

SIL1 or SIL 2 denotes the Safety Integrity Level of the safety device in accordance with the series of standards EN 61508.

Category 1, 2 or 3: The respective category is defines in EN 13237 [1].

"-" means that no safety device is required.

Equipment that contains a potential ignition source is not included in this table, as it has already been designed according to the types of protection.

# Principles of Explosion-Protection

## Marking according to Directive 94/9/EC

### Marking of electrical equipment for use in hazardous areas with flammable gases, vapours or mists or combustible dusts in accordance with the requirements of Directive 94/9/

The following minimum data shall be affixed to each piece of equipment or protective system:

- name and address of manufacturer,
- CE marking (see Annex X, Point A)
- designation of series and type
- serial number, if any
- year of construction,
- the specific marking for explosion-protection

followed by



- the symbol for the equipment group (I or II) and category (M1 or M2 or 1, 2 or 3)
- letter «G» for equipment group II (for areas in which explosive mixtures of gas, vapour or mist with air are present) and/or
- letter «D» (for areas in which dust can form explosive atmospheres)
- furthermore, where necessary, they shall be marked with all information essential to their safe use



## Supplementary requirements of standard EN 60079-0

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Gas: a) Ex symbol

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Gas: b) Type of protection

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Gas: c) Group

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Gas: d) Temperature class

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Gas: e) Equipment protection level

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Dust: a) Ex symbol

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Dust: b) Type of protection

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Dust: c) Group

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Dust: d) Max. surface temperature

II 2G Ex d e IIC T4 Gb  
II 2D Ex tb IIIC T80°C Db

Dust: e) Equipment protection level

Lamp: G13-81-IEC  
IP 66

Dust: f) Degree of protection

### Supplementary requirements of standard EN 60079-0

- Name or symbol of the notified body.
- If it is necessary to indicate that specific conditions of use apply, the symbol "X" shall be added after the certificate number.

### Ex marking for explosive gas atmospheres

- a) the symbol Ex, which indicates that the electrical equipment satisfies the requirements of one or more types of protection,
- b) the symbol for each type of protection used:
  - "d": flameproof enclosure (for EPL Gb or Mb)
  - "e": increased safety (for EPL Gb or Mb)
  - "ia": intrinsic safety (for EPL Ga or Ma)
  - "ib": intrinsic safety (for EPL Gb or Mb)
  - "ic": intrinsic safety (for EPL Gc)
  - "ma": encapsulation (for EPL Ga or Ma)
  - "mb": encapsulation (for EPL Gb or Mb)
  - "mc": encapsulation (for EPL Gc)
  - "nA": type n, type of protection nA (for EPL Gc)
  - "nC": type n, type of protection nC (for EPL Gc)
  - "nR": type n, type of protection nR (for EPL Gc)
  - "o": oil immersion (for EPL Gb)
  - "p": pressurization, category "px" (for EPL Gb or Mb)
  - "p": pressurization, category "py" (for EPL Gb)
  - "p": pressurization, category "pz" (for EPL Gc)
  - "q": powder filling (for EPL Gb or Mb)
- c) the symbol for the group:
  - I for electrical equipment for mines susceptible to firedamp

IIA, IIB or IIC for electrical equipment for use in all areas with an explosive gas atmosphere except for mines susceptible to firedamp.

- d) For group II electrical equipment, the symbol indicating the temperature class:
- e) the equipment protection level „Ga“, „Gb“ or „Gc“ as appropriate.

### Ex marking for explosive dust atmospheres

- a) the symbol "Ex", which indicates that the electrical equipment satisfies the requirements of one or more types of protection
  - b) the symbol for each type of protection used:
    - "ta": protection by enclosure (for EPL Da)
    - "tb": protection by enclosure (for EPL Db)
    - "tc": protection by enclosure (for EPL Dc)
    - "ia": intrinsic safety (for EPL Da)
    - "ib": intrinsic safety (for EPL Db)
    - "ic": intrinsic safety (for EPL De) – under revision
    - "ma": encapsulation (for EPL Da)
    - "mb": encapsulation (for EPL Db)
    - "mc": encapsulation (for EPL Dc)
    - "p" pressurization (for EPL Db or Dc)
  - c) the symbol for the group IIIA, IIIB or IIIC for electrical equipment in areas with an explosive dust atmosphere,
  - d) the maximum surface temperature in degrees Celsius and the unit of measurement °C preceded by the letter "T" (e.g. T 90°C).
  - e) the equipment protection level "Da", "Db" or "Dc" as appropriate.
  - f) the degree of protection (e. g. IP54).
- The Ex marking for explosive gas atmospheres and explosive dust atmospheres must not be combined, but shall be stated separately.

# Principles of Explosion-Protection

## Requirements for the erection, operation, maintenance and repair of electrical installations in hazardous areas

### Requirements for the erection, operation, maintenance and repair of electrical installations in hazardous areas

#### Rules, regulations and ordinances

The following shall be observed for the erection and operation of electrical installations in hazardous areas:

- Ordinance governing the health and safety aspects of the provision of work equipment and use of materials at work, the operation of equipment requiring supervision and the organization of occupational health and safety precautions (Betriebssicherheitsverordnung - BetrSichV)
- Ordinance concerning the placing on the market of equipment and protective systems intended for use in hazardous areas– Explosion-protection decree (ExVO)
- Approximation of the laws of the member states concerning equipment and protective systems intended for use in potential explosive atmospheres (94/9/EC)
- Minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (1999/92/EC)
- Explosion-protection rules (EX – RL) with examples from the “BG-Chemie“ (Employers’ Liability Association for the chemical industry)
- Directives for the avoidance of ignition hazards due to electrostatic charges issued by the Confederation of the Insurance Liability Associations
- Accident prevention regulations of the Employers’ Liability Association BGV A2 “Electrical installations and equipment”

On principle, the following VDE regulations apply for the erection of electrical installations:

- VDE 0100, 0101, 0107, 0113, 0141, 0185, 0190, 0800 Parts 1 – 4.

### In addition, the following VDE regulations shall be taken into consideration for hazardous areas:

- VDE 0165 and VDE 0170 (all parts).  
The following applies for the operation and servicing of existing installations
- VDE 0105 Operation of electrical installations – Part 1:  
General stipulations

#### Engineering and construction

##### EN 60079-14

#### Explosive atmospheres - Part 14: Electrical installations design, selection and construction

This standard contains the specific requirements for the design, selection and erection of electrical installations in explosive atmospheres. If the equipment is to be protected against other environmental conditions, e.g. against the ingress of water or against corrosion, additional protection measures may be necessary. These measures should not adversely affect the integrity of the enclosure.

The requirements of this standard only apply to the use of equipment under normal or near normal atmospheric conditions. Additional precautionary measures may be necessary for other conditions. For example, most flammable materials and many materials that are normally regarded as being non-flammable might burn vigorously under conditions of oxygen enrichment.

Further precautionary measures might also be necessary for the use of electrical equipment under extreme temperature or extreme pressure conditions. Such precautionary measures do not come under the scope of this standard.

These requirements supplement the requirements / standards for installations in non-hazardous areas.

This standard applies to all electrical equipment including fixed, portable, transportable and handheld equipment and permanent or temporary installations. It applies to all installations at all voltages.

## Electrical installations design, selection and erection to EN 60079-14

This standard does not apply to:

- electrical installations in mines susceptible to firedamp;
- inherently explosive situations, e.g. the manufacture and processing of explosives;
- rooms for medical purposes;
- electrical installations in areas where the hazard is due to hybrid mixtures of combustible dust and an explosive gas vapour or mist.

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

The following table of contents gives an overview of the requirements included in the standard:

1.	Scope	6.1	Danger from live parts
2.	Normative references	6.2	Danger from exposed and extraneous conductive parts
3.	Terms and definitions	6.3	Potential equalization
4.	General	6.4	Static electricity
4.1	General requirements	6.5	Lightning protection
4.2	Documentation	6.6	Electromagnetic radiation
4.3	Assurance of conformity of equipment	6.7	Cathodically protected metal parts
4.4	Qualifications of personnel	6.8	Ignition by optical radiation
5.	Selection of electrical equipment (excluding cables and conduits)	7.	Electrical protection
5.1	Information requirements	7.1	General
5.2	Zones	7.2	Rotating electrical machines
5.3	between equipment protection levels (EPLs) and zones	7.3	Transformers
5.4	Selection of equipment according to	7.4	Resistance heating devices
5.5	Selection according to equipment grouping	8	Emergency switch-off and electrical isolation
5.6	Selection according to the ignition temperature of the gas, vapour or dust and ambient temperature	8.1	Emergency switch-off
5.7	Selection of radiating equipment for dust	8.2	Electrical isolation
5.8	Selection of ultrasonic equipment for dust	9	Wiring systems
5.9	External influences	9.1	General
5.10	Light metals as construction materials	9.2	Aluminium conductors
5.11	Transportable, portable and personal electrical equipment	9.3	Cables
5.12	Selection of rotating electrical machines	9.4	Conduit systems
5.13	Luminaires	9.5	Cables and conduit systems
5.14	Plugs and socket outlets for dust	9.6	Installation requirements
6	Protection from dangerous (incendive) sparking	10	Additional requirements for type of protection "d" -Flameproof
		10.1	General
		10.2	Solid obstacles
		10.3	Protection of flameproof joints
		10.4	Cable entry systems
		10.5	Conduit systems
		10.6	Motors
		11	Additional requirements for type of protection "e" -Increased safety
		11.1	Degree of ingress protection of enclosures (IEC 60034-5 and IEC 60529)
		11.2	Wiring systems
		11.3	Cage induction motors
		11.4	Luminaires
		12	Additional requirements for type of protection "i" -Intrinsic safety
		12.1	Introductory remarks
		12.2	Installations to meet the requirements of EPLs , "Gb" and "Gc"
		12.3	Installations to meet the requirements of EPL "Ga",
		12.4	Special applications
		13	Additional requirements for pressurized enclosures
		13.1	Type of protection "p"
		13.2	Motors
		13.3	Type of protection "pD"
		13.4	Rooms for explosive gas atmospheres

# Principles of Explosion-Protection

## Electrical installations design, selection and erection to EN 60079-14

- 14 Additional requirements for type of protection “n”
  - 14.1 General
  - 14.2 Degree of ingress protection of enclosures(IEC 60034-5 and IEC 60529)
  - 14.3 Wiring systems
  - 14.4 Motors
  - 14.5 Luminaires
- 15 Additional requirements for type of protection “o” – Oil immersion
- 16 Additional requirements for type of protection “q” – Powder filling
- 17 Additional requirements for type of protection “m”- Encapsulation
- 18 Additional requirements for type of protection “Ex tD” – Protection by enclosure

### Brief information on selected items:

#### Potential equalization

To prevent incendive sparking, potential equalization is required for installations in hazardous areas. All conductive parts that are part of the structure or electrical installation and where a potential shift is to be expected shall be connected to the equipotential bonding system.

Examples where additional potential equalization measures are required:

- pipes insulated via compensators (non-conductive)
- insulated sealing gaskets

The following need not be connected to the equipotential bonding system:

- conductive window frames
- conductive door frames

Enclosures need not be additionally connected to the equipotential bonding system if, due to their fixing method, they have reliable contact to parts of installations that are included in the equipotential bonding system.

#### Lightning protection systems

A functional lightning protection system is required in hazardous areas. The individual requirements can be found in VDE 0185, Part 2. In EN 60 079-14 only includes the protective aim, whereby the effects of lightning shall be reduced to a safe level. A lightning protection device is only prescribed for intrinsically safe circuits that are fed into Zone 0.

#### Electrostatic charges

The requirements that apply to equipment (see EN 60079-0) are also relevant for all other chargeable components and shall be taken into consideration during the erection and operation of installations.

#### Emergency switch-off

Means for switching off the electrical supply of the hazardous areas in the event of an emergency shall be available outside the hazardous area.

#### Isolation

In addition, to allow work to be carried out safely, a suitable means of isolation with a label to identify the respective circuit shall be provided for each circuit (or each group).



## Electrical installations design, selection and erection to EN 60079-14

### Wiring systems

Wiring systems shall always be selected so as to ensure that they withstand the mechanical, electrical, chemical and thermal stresses that are to be expected. Cables that are not laid in earth or in sand-filled cable trenches / ducts shall be protected against flame propagation.

Bushings for cables into non-hazardous areas shall be adequately sealed (e.g. sand seals or mortar sealing). Where cables are subject to particular stresses, they shall be specially protected (e.g. by conduit).

However, closed conduit systems must not be laid unless, due to their specific design, they are suitable for hazardous areas.

### Additional requirements

In addition to the basic requirements that have already been described, the standard also contains additional requirements according to the type of protection and/or equipment.

### Commissioning of electrical installations in hazardous areas

After erection, in accordance with §14 of the BetrSichV, the operator shall have the proper state of an installation inspected by a qualified person prior to commissioning.

Until now in Germany, a qualified person for electrical installations in hazardous areas is a qualified electrician who shall, of course, have a special knowledge of explosion protection. The state of the art technologies shall be applied as the basis for this inspection.

The inspection may also be carried out by a suitably trained specialist from an outside company. The results of the inspection shall be recorded (§ 19 BetrSichV).

If the planner and the installer come from different companies, the areas of accountability shall be clearly defined and coordinated.

With intrinsically safe circuits, the planning criteria for the verification of the intrinsic safety shall be coordinated with the installation, as changes to the installation may affect the verification of the intrinsic safety.



# Principles of Explosion-Protection

## Operation of electrical installations in hazardous areas

### Operation of electrical installations in hazardous areas

After an installation has been erected correctly, it shall be operated in accordance with the state of the art technology. In accordance with the European Directive 1999/92/EC, the responsible operator shall observe the following important principles:

- Maintenance of the proper state of electrical installations
- Supervision of the electrical installation
- Immediate execution of necessary repair work
- Discontinuation of operation in the event of non-rectifiable faults that may endanger personnel
- Maintenance of explosion-protected equipment

After commissioning, it is necessary to ensure that the proper state is maintained. For this the installations shall be inspected at given intervals on a recurrent basis, at the least every 3 years. EN 60079-17 can be referred to for details relating to the execution of these inspections. When work is being carried out in hazardous areas, the safety of persons and installations is dependent to a large degree on the strict adherence to all safety regulations.

The company management and the operating and maintenance personnel shall work together in an optimal way to ensure the maximum possible degree of safety. Thus, the maintenance staff that works in such installations bears a special responsibility.

### Maintenance

Maintenance encompasses all measures (inspection, servicing and repair) for maintaining and restoring the required state and for determining and assessing the actual state. Inspections or the supervision of installations helps to prepare for upcoming maintenance tasks and to identify trends with regard to possible damages. A visual inspection shows the experienced specialist, e.g. due to the formation of droplets on switch cabinets, whether more intensive inspections are necessary.

### Special safety measures

Whenever work is carried out in hazardous areas, it is necessary to ensure that neither incandescence sparks nor hot surfaces occur that, in combination with an explosive atmosphere, can lead to an explosion. On principle, work on live electrical installations and equipment is strictly forbidden. By way of exception, work on intrinsically safe circuits and, in certain cases, on other electrical installations is permitted.

In this case, the company management shall issue a safe work permit to confirm in writing that no explosion hazard exists at the work-site for the duration of the work in hand. The absence of voltage may only be measured with explosion-protected measuring instruments. The two special cases named above are the only exceptions. Earthing or short-circuiting in hazardous areas is only permitted if no explosive atmosphere is present.



## Operation of electrical installation in hazardous areas

### Avoidance of formation of sparks

With the electrical equipment used, the respective types of protection ensure that no incendive sparks or hot surfaces come into contact with the explosive atmosphere. If no further organizational measures have been taken, only explosion-protected measuring instruments may be used to measure electrical values. Sparks capable of causing ignition may also occur when connecting or disconnecting cables, even though no voltage source is connected.

The reasons for this can be stored energy in electrical installations or external influences such as induction of electromagnetic fields. The electrician shall, at all times, be aware of whether or not sparks capable of causing ignition are to be expected.

A possible spark formation shall also be taken into account when using hand-operated tools. Here a distinction is made between two types of tools, tools where only single sparks occur during use, e.g. screwdrivers or spanners, and tools that give off a shower of sparks during use, e.g. grinders.

The use of tools that may give off sparks is generally not permitted in zones 0 and 20. According to EN 1127, only those steel tools that might give off a single spark can be used in zones 1 and 2 if no Group IIC substances are present. The use of steel tools that give off single sparks is permitted in zones 21 and 22.

On principle, tools that give off sparks may only be used together with a "safe work permit" if the location has been assessed to ensure that an explosive atmosphere is not present for the duration of the work-in-hand. The requisite safety measures shall be specified in the safe work permit.

**Hot work permit for hazardous areas**  
Tick off where applicable. Delete what is not applicable in lines ticked off.

**Permit for welding, burning and other hot work, for drilling, grinding, impact and calking work, for the use of non-explosion protected apparatus.**

**A** 1. Contractor: \_\_\_\_\_ Building: \_\_\_\_\_ Tel.: \_\_\_\_\_ Foreman: \_\_\_\_\_  
 2. Place and kind of work \_\_\_\_\_  
 3. Hot work permit from \_\_\_\_\_ o'clock to \_\_\_\_\_ o'clock, for the time \_\_\_\_\_  
 4. For workshop/Messrs \_\_\_\_\_ Building \_\_\_\_\_ Foreman: \_\_\_\_\_

B Dangerous places in the environment of the workplace, buildings, equipment etc.	Person responsible	Building	Tel.
1.			
2.			
3.			
4.			

**C Security precautions** To be executed by: \_\_\_\_\_ Settled \_\_\_\_\_

1. Checking the tightness of pipes, equipment in the environment of the workplace \_\_\_\_\_

2. Fire fighting and other security precautions \_\_\_\_\_

a. Placing in readiness at the workplace of water for fire fighting and fire extinguishers \_\_\_\_\_

b. Connecting the fire hose \_\_\_\_\_

c. Placing look-out man \_\_\_\_\_  
 craftsman  staff member  supervisor  fireman \_\_\_\_\_

d. Removal of inflammable substances, vapours, gases or dust deposits \_\_\_\_\_

e. \_\_\_\_\_

f. \_\_\_\_\_

3. Signposting of the workplace (road, railroad tracks etc.) \_\_\_\_\_

a. By means of red flags (20 m on either side of the workplace) \_\_\_\_\_

b. By means of signs (e.g. hot work on pipe bridge) \_\_\_\_\_

c. Blockage, diversion for tank lorries, blockage for rail cars \_\_\_\_\_

4. Protection of the environment from welding sparks \_\_\_\_\_

a. Covering of the adjacent conduits \_\_\_\_\_

b. Setting up of a protective wall, protection of the roof surface, possibly keeping wet \_\_\_\_\_

c. Stopping of hot work with running of trains \_\_\_\_\_

d. Keeping a min. distance of \_\_\_\_\_ m from tank wagons, tank farms etc. with fire hazard \_\_\_\_\_

e. Covering and sealing of pipe openings, gratings, light wells and gully holes \_\_\_\_\_

f. \_\_\_\_\_

5. In case of hot work in and on containers, apparatus, pits, pipework, dismantled parts of installations, in confined rooms etc. Additional measures such as: \_\_\_\_\_

a. Travelling permit No. \_\_\_\_\_ dated \_\_\_\_\_

b. Work permit No. \_\_\_\_\_ dated \_\_\_\_\_

c. Test certificate for electrical apparatus No. \_\_\_\_\_ dated \_\_\_\_\_

d. \_\_\_\_\_

6. \_\_\_\_\_

a. Before starting to work, **daily** report to B 1, 2, 3, 4. \_\_\_\_\_

b. Report end of the work **daily** to B 1, 2, 3, 4. \_\_\_\_\_

7. \_\_\_\_\_

a. Check of the security precautions ticked off by (name) \_\_\_\_\_

b. Check of the workplace after ending the work by (name) \_\_\_\_\_

**C Consent of responsibilities for the dangerous places** Starting time reported on: \_\_\_\_\_ to: \_\_\_\_\_

For B 1 measures C figure \_\_\_\_\_

For B 2 measures C figure \_\_\_\_\_

For B 3 measures C figure \_\_\_\_\_

For B 4 measures C figure \_\_\_\_\_

Date \_\_\_\_\_ Signatures \_\_\_\_\_

**Hot work permit issued** \_\_\_\_\_

Date \_\_\_\_\_ Signature of the works supervisor or his mandatory \_\_\_\_\_

Look-out man (name) \_\_\_\_\_

Example of a safe work permit

# Principles of Explosion-Protection

## EN 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance

### EN 60079-17

#### Explosive atmospheres - Part 17: Electrical installations inspection and maintenance

Electrical installations in hazardous areas have features that are specially designed to render them suitable for operations in such atmospheres. For safety reasons, it is essential that the integrity of these features is preserved throughout the service life of such installations. This requires an initial inspection followed by

- a) regular periodic inspections
- b) or continuous supervision by skilled personnel and, where necessary, maintenance work.

This standard, which is aimed at users, only covers aspects that are directly related to the inspection and maintenance of electrical installations in hazardous areas. It does not include:

- other fundamental installations and inspection requirements for electrical installations
- the verification of electrical equipment
- the repair and reclamation of explosion-protected equipment (see EN 60079-19)

It does not apply to:

- underground mining areas,
- areas where a risk can arise due to the presence of hybrid mixtures,
- dust of explosives that do not require atmospheric oxygen for combustion,
- pyrophoric substances.

#### Table of contents of standard (extract):

4	General requirements
4.1	Documentation
4.2	Qualification of personnel
4.3	Inspections
4.4	Periodic inspections
4.5	Continuous supervision by skilled personnel
4.6	Maintenance requirements
4.7	Environmental conditions
4.8	Isolation of equipment
4.9	Earthing and equipotential bonding
4.10	Specific conditions of use
4.11	Moveable equipment and its connection
4.12	Inspection schedules (Tables 1 to 4)

#### Definitions:

##### Visual inspection

An inspection that identifies, without the use of access equipment or tools, those defects such as missing screws that are apparent to the eye.

##### Close inspection

An inspection that encompasses those aspects covered by a visual inspection and, in addition, identifies those defects, such as loose screws, that will only be apparent by the use of access equipment, e.g. steps (where necessary) and tools.

##### NOTE:

Close inspections do not usually require the enclosure to be opened or the equipment to be de-energized.

##### Detailed inspection

An inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those defects, such as loose terminations, that will only be apparent by opening the enclosure and/or, where necessary, using tools and test equipment.

##### Continuous supervision

Frequent attendance, inspection, service, care and maintenance of the electrical installation by skilled personnel who have experience in the specific installation and its environment in order to maintain the explosion-protection features of the installation in a satisfactory condition.

## EN 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance

### Skilled personnel

Persons whose training has included instruction on the various types of explosion-protection and installation practices, the requirements of this standard, the relevant national regulations and company rules applicable to the installation and on the general principles of area classification.

### Documentation

For the purposes of inspection and maintenance, up-to-date documentation of the following information shall be available:

- a) zone classification of areas and, if included, the EPL (equipment protection level) required for each location (see EN 60079-10)
- b) for gases:  
equipment group (IIA, IIB or IIC) and temperature class requirements
- c) for dusts:  
equipment group (IIIA, IIIB or IIIC) and maximum surface temperature requirements
- d) equipment characteristics, e.g. temperature ratings, type of protection, IP rating, corrosion resistance
- e) appropriate documentation to allow the explosion-protected equipment to be maintained in accordance with its type of protection (e.g. list and location of equipment, spare parts and technical information)
- f) copies of previous inspection records

### Inspections

Before an installation or equipment is put into service, it shall be given an initial inspection. To ensure that installations in hazardous areas are maintained in a satisfactory condition for continued use, either

- a) regular, periodic inspections, or
- b) continuous supervision by skilled personnel and, where necessary, maintenance work shall be carried out.



Explosion-protected cap and hand lamps for a safe and flexible illumination of work areas during inspections and maintenance work

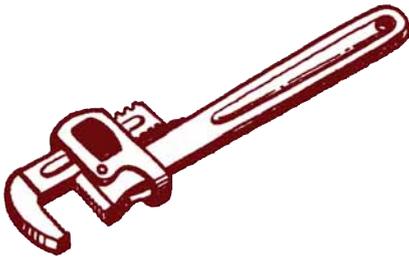


## EN 60079-19 Equipment repair, overhaul and reclamation

### Repair of explosion-protected equipment

After the repair of parts on which the explosion-protection depends, equipment shall be inspected by an authorized inspection body or an authorized, competent person. (In Germany § 14 (6) BetrSichV applies).

If the result is positive, the authorized inspection body or, as the case may be, the competent person shall issue a test certificate or affix a test symbol to the equipment. Only then may the equipment be put back into service. This inspection can be omitted if the repairs are carried out by the manufacturer of the equipment and renewed routine tests have been carried out. Repair and modification of the equipment have to be done in accordance to EN 60079-19.



### EN 60079-19

**Warning: This standard applies for the overhaul of equipment. National requirements may differ and shall be observed!**

### Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation

This standard contains general requirements and requirements relating to specific types of protection for the repair and overhaul of equipment. In cases where explosion-protected equipment incorporates more than one type of protection, the requirements for all the types of protection shall be taken into consideration.

It is not only a guideline for the practical possibilities for the ongoing fulfilment of the requirements relating to the electrical safety and mode of operation of repaired apparatus. It also specifies procedures for maintenance work after repair, overhaul or regeneration, for the adherence to the stipulations of the type examination certificate of the stipulations of the respective standards for explosion-protection – if no certificate is available.

#### Definitions:

#### Repair

An action to restore faulty equipment to its fully serviceable condition in compliance with the relevant standard.

#### Overhaul

An action to restore equipment which has been in use or in storage for a period of time, but which is not faulty, to a fully serviceable condition.

#### Maintenance

Routine actions taken to preserve the fully serviceable condition of the installed equipment.

#### Reclamation

A means of repair involving, for example, the removal or addition of material to reclaim component parts which have sustained damage, in order to restore such parts to a serviceable condition in accordance with the relevant standard.



# Principles of Explosion-Protection

## EN 60079-19: Equipment repair, overhaul and reclamation

### General principles

Provided that repairs and overhauls are carried out using good engineering practices, compliance of the equipment with the certificate shall be presumed:

- a) if parts prescribed by the manufacturer or parts specified in the certification documents are used for repair or overhaul work

or

- b) the equipment complies with the certificate if repairs or alterations to equipment carried out are as comprehensive as those listed in the certification documents.

In the event that the certification documents are not available, the repair or overhaul of equipment shall be carried out in accordance with this standard and other relevant standard(s). If the techniques applied for the repair or overhaul do not comply with this standard, the manufacturer and/or certification body shall determine, whether the equipment is suitable for continued use in a hazardous area. The person/company responsible for the repair or overhaul of equipment shall ensure that the persons directly involved with the repair and/or overhaul of the certified equipment are trained, experienced, qualified and competent or they shall be supervised when carrying out such work. Appropriate training and assessment shall be undertaken from time to time at intervals depending on the frequency of utilization of the technique or skill and change of standards or regulations. The interval should normally not exceed three years.

### Identification of repaired equipment by marking

Repaired and overhauled equipment shall be marked in a clearly visible position on the main part.

The marking shall include:

- the relevant symbol
- the standard number "IEC 60079-19" or national equivalent;
- the name of the repairer or his registered trade mark and repair facility certification;
- the date of the overhaul/repair.

### Replacement of equipment

With regard to explosion-protection, equipment (with the exception of intrinsically safe installations and equipment,) work may only be carried out on electrical installations and in rooms with an explosive atmosphere if they are de-energized or if a permit issued by the authorized operations manager for work with ignition hazards with the requisite safety measures is available and these safety measures have already been carried out.

When replacing electrical equipment, it is necessary to pay attention to their intended, i.e. the temperature class, explosion class and (Ex) zone or equipment category. The requisite test certificates or declaration of conformity issued by the manufacturer and the associated operating instructions shall be available.

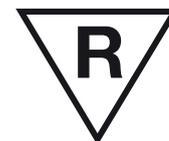
In the case of motors in the type of protection Ex-e, it is necessary to take the time  $t_E$  into account. Lamps may only be replaced by lamps that correspond to the details stated on the luminaire with regard to the rating and type. In the case of special lamps, only lamps with the identification number stated on the rating label of the luminaire may be used. After completion of work:

- cable ducts shall be filled with sand or well ventilated and drained,
- openings for cables leading into non-hazardous areas shall be tightly sealed again,
- unused cable entries of electrical equipment shall be sealed and safeguarded against self-loosening,
- cable glands shall be tight.

### Symbols



Compliance with certification and/or specifications of manufacturer



Compliance with standards, but not with certification documents

## Definition of hazardous areas and requirements for explosion-protected electrical equipment on the world market

### Summary of the explosion-protection measures, standards, categories and classifications that exist throughout the world:

On the world market hazardous areas are either classified into areas with different degrees of hazard according to IEC publication IEC 60079-10 (in Europe EN 60079-10) or the NEC (National Electrical Code).

The following is a brief overview of the NEC requirements and a comparison of the requirements/specifications according to IEC (EN) and NEC.

Detailed information can be found in the latest Crouse-Hinds Digest.

This publication can be downloaded as a PDF file on the homepage of Cooper Crouse-Hinds „www.coopercrouse-hinds.com“

#### NEC:

Classification according to the explosive medium:

- Class I - Mixtures of flammable or explosive gases our vapours with air
- Class II - Mixtures of combustible dust with air
- Class III - Mixtures of easy ignitable fibres with air

Classification of hazardous areas:

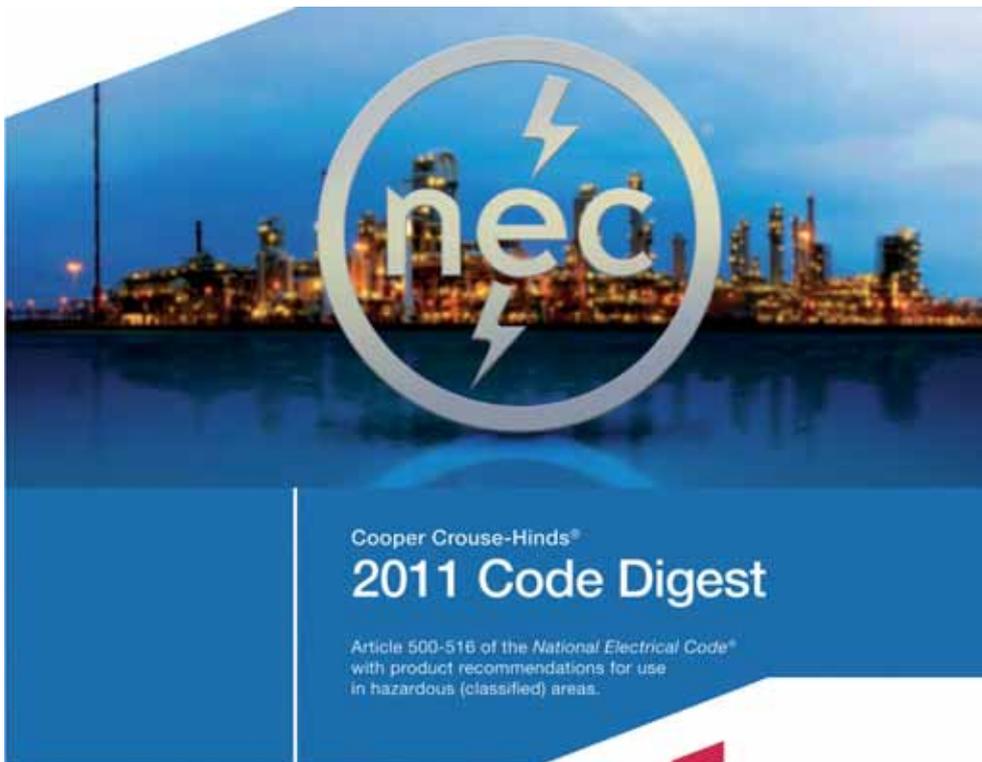
#### Division 1

Locations in which flammable gases or vapours may exist under normal operating conditions:

- during repair or maintenance operations,
- whether broken down or faulty
- operation of process equipment- might also cause the simultaneous failure of electrical equipment

#### Example:

Class I, Division 1 areas would include locations where flammable liquids or gases are transferred from one container to another.



**COOPER** Crouse-Hinds



NEC Code Digest from Cooper Crouse-Hinds, USA

# Principles of Explosion-Protection

## Definition of hazardous areas and requirements for explosion-protected electrical equipment on the world market

### Division 2

Locations where volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment.

#### Example:

Class I, Division 2 areas would include locations where tanks are stored.

### Groupings of explosive mixtures

Group A	Acetylene
Group B	Hydrogen
Group C	Ethylene
Group D	Propane
Group E	Metal dust
Group F	Coal dust
Group G	Grain dust

### Temperature classes (T-Codes):

T1	max.	450°C
T2	max.	300°C
T2A	max.	280°C
T2B	max.	260°C
T2C	max.	230°C
T2D	max.	215°C
T3	max.	200°C
3A	max.	180°C
T3B	max.	165°C
T3C	max.	160°C
T4	max.	135°C
T4A	max.	120°C
T5	max.	100°C
T6	max.	85°C

### Comparison NEC 500 with NEC 505 (IEC/EN):

Example	NEC 500-503	NEC 505
<b>Class I Gases and Vapours</b>		
Acetylene	Group A	Group IIC
Hydrogen	Group B	Group IIC
Ethylene	Group C	Group IIB
Propane	Group D	Group A
<b>Class II Dusts</b>		
Metal dust	Group E	
Coal dust	Group F	
Grain dust	Group G	
<b>Class III Fibres &amp; Flyings</b>		
Wood/paper		no groups

Categories of gas groups:

### Temperature classification

Maximum surface temperature	IEC NEC® 505	NEC 500 - Table 500.8 (C)
450°C (842°F)	T1	T1
300°C (572°F)	T2	T2
280°C (536°F)		T2A
260°C (500°F)		T2B
230°C (446°F)		T2C
215°C (419°F)		T2D
200°C (392°F)	T3	T3
180°C (356°F)		T3A
165°C (329°F)		T3B
160°C (320°F)		T3C
135°C (275°F)	T4	T4
120°C (248°F)		T4A
100°C (212°F)	T5	T5
85°C (185°F)	T6	T6

## Global reference guide for potentially explosive atmospheres and hazardous locations

### Ingress protection codes (IP) according IEC 60529

<b>FIRST NUMERAL</b> Protection against solid bodies		<b>SECOND NUMERAL</b> Protection against liquid
0 - NO PROTECTION	<b>IP56</b>	0 - NO PROTECTION
1 - OBJECTS EQUAL TO OR GREATER THAN 50 mm		1 - VERTICALLY DRIPPING WATER
2 - OBJECTS EQUAL TO OR GREATER THAN 12.5 mm		2 - 75° TO 105° ANGLED DRIPPING WATER
3 - OBJECTS EQUAL TO OR GREATER THAN 2.5 mm		3 - SPRAYING WATER
4 - OBJECTS EQUAL TO OR GREATER THAN 1.0 mm		4 - SPLASHING WATER
5 - DUST-PROTECTED		5 - WATER JETS
6 - DUST-TIGHT		6 - HEAVY SEAS; POWERFUL WATER JETS
		7 - EFFECTS OF IMMERSION
		8 - INDEFINITE IMMERSION

### NEMA enclosure types

Enclosure Intended use type	Equivalent IP rating*
1 Indoor use, limited amounts of falling dirt	20
3 Outdoor use, rain, sleet, windblown dust, external formation of ice	55
3R Outdoor use, rain, sleet, external formation of ice	54
3S Outdoor use, rain, sleet, windblown dust, external mechanisms operable when ice laden	55
4 Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, external formation of ice	56
4X Indoor or outdoor use, windblown dust and rain, splashing water, hose directed water, corrosion, external formation of ice	56
5 Indoor use, settling airborne dust, falling dirt, non-corrosive liquids	53
6 Indoor or outdoor use, hose directed water, temporary submersion, external formation of ice	67
6P Indoor or outdoor use, hose directed water, prolonged submersion, external formation of ice	68
7** Indoor use, Class I, Division 1, Groups A, B, C, and D hazardous locations, air-break equipment	
8** Indoor or outdoor use, Class I, Division 1 Groups A, B, C, and D hazardous locations, oil-immersed equipment	
9** Indoor use, Class II, Division 1, Groups E, F, and G hazardous locations, air-break equipment	
10** Mining applications	
12 Indoor use, circulating dust, falling dirt, dripping noncorrosive liquids	54
12K Indoor use, circulating dust, falling dirt, dripping noncorrosive liquids, provided with knockouts	54
13 Indoor use, lint, dust, spraying of water, oil and noncorrosive coolant	54

\* NEMA Enclosure Type can be converted to IP Code rating, but IP Codes cannot be converted to NEMA Enclosure Type (Ref. NEMA 250)

\*\* Enclosure Types for U.S. only (Ref. NEMA 250)

# Principles of Explosion-Protection

Global reference guide for potentially explosive atmospheres  
and hazardous locations:  
NEC/CEC reference

Typical NEC/CEC Product markings				NEC 500		
	Class I	Division 1	Groups A, B, C & D	T6	Class I	Zone 1
Hazard Category						
Area Classification						
Hazardous Atmosphere Category (Gas or Dust Grouping)						
Temperature Classification						
Hazard Category						
Area Classification						
Explosion-Protection Standard (EX-IEC/ATEX/CEC, AEx-NEC)						
Method of Explosion-Protection						
Hazardous Atmosphere Category (Gas or Dust Grouping)						
Temperature Classification						

## Hazardous atmosphere category (gas or dust grouping)

Explosive atmosphere	Typical hazard material	North America NEC 500-503 / CEC 18		NEC 505*/CEC 18
		Hazard category	Grouping	Gas-Grouping
Gases and vapours	Acetylene	Class I	Group A	IIC
	Hydrogen	Class I	Group B	IIC or IIB+H2
	Ethylene	Class I	Group C	IIB
	Propane	Class I	Group D	IIA
Dust	Metal dust	Class II	Group E	-
	Coal dust	Class II	Group F	-
	Grain dust	Class II	Group G	-
Fibres & Flyings	or cotton processing			

\* NEC 505 covers explosive gases and vapors only.

## Global reference guide for potentially explosive atmospheres and hazardous locations: NEC/CEC reference

### NEC 505 / CEC 18

**AEx**      **e**      **IIC**      **T6**

**CENELEC** (European Committee for Electrotechnical Standardization) publishes standards covering the electrotechnical field for countries in Europe.

**INTERNATIONAL ELECTROTECHNICAL COMMISSION** (IEC) global organization that prepares and publishes international standards for electrical, electronic and related technologies.

**NEMA** (National Electrical Manufacturers Association) NEMA 250 series standards for enclosure types covers both hazardous areas (potentially explosive atmospheres) and non-hazardous areas.

**NEC** – National Electrical Code (USA)

**CEC** – Canadian Electrical Code (Canada)

### Area classification

North America/	Continuous hazard	Intermittent hazard	Hazard under abnormal conditions
NEC 500-503/ CEC 18	Division 1	Division 1	Division 2
NEC 505-506/ CEC 18	Zone 0 (Zone 20 dust)	Zone 1 (Zone 21 dust)	Zone 2 (Zone 22 dust)

### Method of explosion-protection

Type of protection	Description of protection	Permitted for use in				Protection concept
		United States NEC 500 Division	NEC 505 Zone	Canada CEC 18 Division	CEC 18 Zone	
e	Increased safety	-	1, 2	-	1, 2	No arcs, sparks or hot surfaces
n	Non incendive	2	2	2	2, 0	
d	Flameproof	-	1, 2	-	1, 2	Contain the Explosion prevent the flame propagation
-	Explosionproof	1, 2	-	1, 2	-	
q	Powder filled	-	1, 2	-	1, 2	
ia	Intrinsic safety	1, 2	0, 1, 2	1, 2	1, 2	Limit the energy of the spark and the surface temperature
ib	Intrinsic safety	-	1, 2	-	1, 2	
p	Pressurized (purged)	1, 2	1, 2	1, 2	1, 2	Keep the flammable gas out
m	Encapsulation	-	1, 2	-	1, 2	
o	Oil immersion	2	1, 2	2	1, 2	

# Principles of Explosion-Protection

## Global reference guide for potentially explosive atmospheres and hazardous locations: ATEX/IEC reference

### 94/9/EC (ATEX) Product Markings

### Typical IEC/CENELEC Product Markings

ATEX required markings	GAS					Dust					
	Ex	d	e	IIC	T6	Gb <sup>1)</sup>	Ex	tb	IIIC	T8°C	Db <sup>1)</sup>
Explosion-Protection Marking	Ex										
Equipment group		II	2								
Equipment category			G	/	D						
Explosive Atmosphere suitability (G – gas, vapor or mist)											
Explosive Atmosphere suitability (D – dust)											
Explosion marking											
Type of protection (Gas)											
Explosion group (Gas)											
Temperature class (Gas)											
Equipment protection level (EPL-Gas)											
Explosion-protection marking											
Type of protection (dust)											
Explosion group (dust)											
Max. surface temperature (dust)											
Equipment protection level (EPL dust)											

1) Standard marking - alternate marking possible e.g.: **Ex db eb IIC T6**

### Zone classification / Equipment protection level

Hazardous mixture	Period of presence of the flammable substances	Zone classification	Necessary marking for the equipment				Protection level
			Equipment group	Category	Protection group	EPL Equipment protection level	
Gas Vapor Mist	Continuously for long periods or frequently	Zone 0	II	1 G	II	Ga	very high
	Occasional occurrence	Zone 1	II	2 G	II	Gb	high
	Not likely, but if it does occur only rarely and for a short period	Zone 2	II	3 G	II	Gc	increased
Dust	Continuously for long periods or frequently	Zone 20	II	1 D	III	Da	very high
	Occasional occurrence	Zone 21	II	2 D	III	Db	high
	Not likely, but if it does occur only rarely and for a short period	Zone 22	II	3 D	III	Dc	increased
Methane Coal dust	Mining	Mining	I	M1	I	Ma	very high
	Mining	Mining	I	M2	I	Mb	high

## Global reference guide for potentially explosive atmospheres and hazardous locations: ATEX/IEC reference

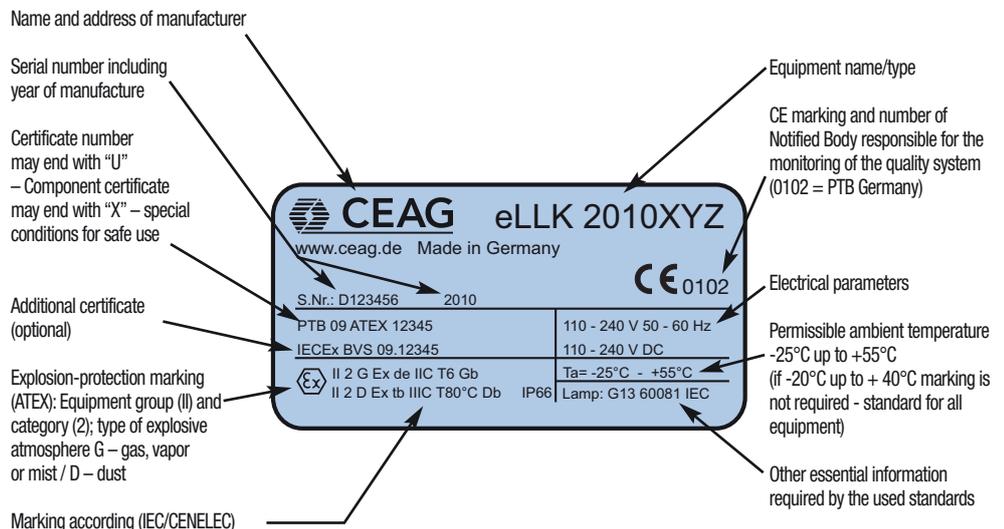
Electrical type of protection for atmospheres made explosive by gases, vapors and mists

Type of protection	Description	Zone	/ATEX category/ EPL	CENELEC /IEC standard	Protection concept	
-	General requirements			EN 60079-0 / IEC 60079-0	-	
d	Flameproof enclosure	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-1 / IEC 60079-1	Contain the explosion, prevent the flame propagation
e	Increased safety	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-7 / IEC 60079-7	No arcs, no sparks, no hot surfaces
ia	Intrinsic safety	Zone 0, 1 or 2	/ 1G	/ Ga	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
ib	Intrinsic safety	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
ic	Intrinsic safety	Zone 2	/ 3 G	/ Gc	EN 60079-11 / IEC 60079-11	Limit the energy of the spark and the surface temperature
	Intrinsically safe systems	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-25 / IEC 60079-25	Limit the energy of the spark and the surface temperature
	Intr. safe Fieldbus sys. (FISCO)	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-27 / IEC 60079-27	Limit the energy of the spark and the surface temperature
	Non-sparking Fieldbus sys. (FNICO)	Zone 1 or 2	/ 3 G	/ Gc	EN 60079-27 / IEC 60079-27	Limit the energy of the spark and the surface temperature
ma	Encapsulation	Zone 0, 1 or 2	/ 1G	/ Ga	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mb	Encapsulation	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mc	Encapsulation	Zone 2	/ 3 G	/ Gc	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
nA	Non-sparking	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	No arcs, no sparks, no hot surfaces
nC	Enclosed break	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	Prevent the flame propagation
nR	Restricted breathing	Zone 2	/ 3 G	/ Gc	EN 60079-15 / IEC 60079-15	Protection by enclosure
o	Oil immersion	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-6 / IEC 60079-6	Exclusion of Ex-atmosphere
op is,	Optical radiation	Zone 0, 1 or 2	/ 1 G, 2 G or 3 G	/ Ga, Gb, Gc	EN 60079-28 / IEC 60079-28	Limit or prevent energy transmission from optical radiation
op pr, op sh	Optical radiation	Zone 1 or 2	/ 2 G or 3 G	/ Gb, Gc	EN 60079-28 / IEC 60079-28	Limit or prevent energy transmission from optical radiation
px, py	Pressurized enclosure	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
pz	Pressurized enclosure	Zone 2	/ 3 G	/ Gc	EN 60079-2 / IEC 60079-2	Exclusion of Ex-atmosphere
q	Powder filling	Zone 1 or 2	/ 2 G	/ Gb	EN 60079-5 / IEC 60079-5	Prevent the flame propagation

Electrical type of protection for atmospheres made explosive by dusts

Type of protection	Description	ATEX Zone	/ATEX category/ EPL	CENELEC /IEC standard	Protection concept	
-	General requirements			EN 60079-0 / IEC 60079-0	-	
ia	Intrinsic safety	Zone 20, 21, 22	/ 1 D	/ Da	EN 61241-11 / IEC 61241-11	Limit the surface temperature
ib	Intrinsic safety	Zone 21, 22	/ 2 D	/ Db	EN 61241-11 / IEC 61241-11	Limit the surface temperature
ma	Encapsulation	Zone 20, 21, 22	/ 1 D	/ Da	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mb	Encapsulation	Zone 21 or 22	/ 2 D	/ Db	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
mc	Encapsulation	Zone 22	/ 3 D	/ Dc	EN 60079-18 / IEC 60079-18	Exclusion of Ex-atmosphere
p	Pressurized	Zone 21 or 22	/ 2 D	/ Db	EN 61241-4 / IEC 61241-4	Exclusion of Ex-atmosphere
t	Protection by enclosure	Zone 20, 21, 22	/ 1 D, 2 D or 3 D	/ Ga, Gb, Gc	EN 60079-31 / IEC 60079-31	Keep the combustible dust out and avoid hot surfaces

Explosion groups		
Explosive atmospheres	Typical hazardous material	Explosion group
Gases and vapors	Acetylene	IIC
	Hydrogen	IIC or IIB+H2
	Ethylene	IIB
	Propane	IIA
Dusts	Metal dust	IIIC
	Coal dust	IIIC
	Grain dust	IIIB
Fibres & Flyings	Wood, paper or cotton processing	IIIA



# Principles of Explosion-Protection

## IP degrees of protection

The IP degrees of protection have been defined in accordance to EN 60529 (protection against accidental contact, foreign matter and water)

<i>Degrees of protection against foreign matter designated by the first code No.</i>		
<b>Degree of protection</b>		
<b>First code No.</b>	<b>Brief description</b>	<b>Definition</b>
0	No special protection	–
1	Protected against solid foreign bodies 50 mm dia. and bigger	The object probe, a ball of 50 mm dia. must not fully penetrate *)
2	Protected against solid foreign bodies 12.5 mm dia. and bigger	The object probe, a ball of 12.5 mm dia. must not fully penetrate *)
3	Protected against solid foreign bodies 2.5 mm dia. and bigger	The object probe of 2.5 mm dia. must not penetrate at all *)
4	Protected against solid foreign bodies 1 mm dia. and bigger	The object probe of 1 mm dia. must not penetrate at all*)
5	Dust protected	Ingress of dust is not totally prevented, but the dust must not enter in such an amount as to interfere with satisfactory operation or with the safety of the apparatus.
6	Dusttight	No ingress of dust

\*) Note: The full diameter of the object probe must not pass through any opening of the enclosure.

<i>Degrees of protection against water designated by the second code No.</i>		
<b>Degree of protection</b>		
<b>Second code No.</b>	<b>Brief description</b>	<b>Definition</b>
0	No special protection	–
1	Protected against dripping water	Vertically falling drops must not have a harmful effect.
2	Protected against dripping water when the enclosure is inclined up to 15°	Drops falling vertically must not have a harmful effect when the enclosure is inclined at an angle up to 15° on either side of the vertical.
3	Protected against spray water	Water being sprayed at an angle of up to 60° on either side of the vertical must not have a harmful effect.
4	Protected against splash-water	Water being splashed against the enclosure from any direction must have no harmful effect.
5	Protected against jet water	Jet water from a nozzle turned on the enclosure from any direction must have no harmful effect.
6	Protected against powerful water jets	There must be no harmful effect from powerful water jets being turned on the enclosure from any direction.
7	Protected against water when the enclosure is immersed in water for a specified time	Water must not enter in harmful quantities when the enclosure is immersed in water at specified conditions of pressure and time.
8	Protected against water when the enclosure is continuously submerged	Water must no enter in such a quantity as might have a harmful effect when the enclosure is continuously submerged in water at conditions which are to be agreed upon between the manufacturer and the user. Conditions must, however, be more stringent than those for code No. 7

## Directives and Standards

EN 1010-1: 2004	Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines - Part 1: Common requirements
EN 1010-2: 2006	Safety of machinery - Safety requirements for the design and construction of printing and paper converting machines - Part 2: Printing and varnishing machines including pre-press machinery
EN 1127-1	Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology
EN 13463-1: 2001	Non-electrical equipment for use in potentially explosive atmospheres - Part 1: Basic method and requirements
EN 13463-2: 2004	Non-electrical equipment for use in potentially explosive atmospheres - Part 2: Protection by flow restricting enclosure 'fr'
EN 13463-3: 2005	Non-electrical equipment for use in potentially explosive atmospheres - Part 3: Protection by flameproof enclosure "d"
EN 13463-5: 2003	Non-electrical equipment intended for use in potentially explosive atmospheres - Part 5: Protection by constructional safety 'c'
EN 13463-6: 2005	Non-electrical equipment for use in potentially explosive atmospheres - Part 6: Protection by control of ignition source "b"
EN 13463-8: 2003	Non-electrical equipment for potentially explosive atmospheres - Part 8: Protection by liquid immersion 'k'
EN 50014 up to EN 50020	Types of protection for explosion-protected apparatus
EN 50281-1-2	Electrical apparatus for use in the presence of combustible dust - Part 2-1: Test methods; methods for determining the minimum ignition temperatures of dust
EN 50495	Safety devices required for the safe functioning of equipment with respect to explosion risks
EN 60079-0	Explosive atmospheres - Part 0: Equipment - General requirements (IEC 60079-0:2007);
EN 60079-1	Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d" (IEC 60079-1:2007)

# Principles of Explosion-Protection

## Directives and Standards

EN 60079-2	Explosive atmospheres - Part 2: Equipment protection by pressurized enclosure "p" (IEC 60079-2:2007)
EN 60079-10	Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres (IEC 60079-10-1:2008)
EN 60079-11	Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i" (IEC 60079-11:2006)
EN 60079-14	Explosive atmospheres - Part 14: Electrical installations design, selection and erection (IEC 31J/196/CD:2011)
EN 60079-15	Explosive atmospheres - Part 15: Equipment protection by type of protection "n" (IEC 60079-15:2010)
EN 60079-17	Explosive atmospheres - Part 17: Electrical installations inspection and maintenance (IEC 60079-17:2007)
EN 60079-18	Explosive atmospheres - Part 18: Equipment protection by encapsulation "m", (IEC 60079-18:2009 + Corrigendum 2009)
EN 60079-19	Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation (IEC 60079-19:2010)
EN 60079-25	Explosive atmospheres - Part 25: Intrinsically safe electrical systems (IEC 60079-25:2010)
EN 60079-26	Explosive atmospheres - Part 26: Equipment with equipment protection level (EPL) Ga (IEC 60079-26:2006)
EN 60079-27	Explosive atmospheres - Part 27: Fieldbus intrinsically safe concept (FISCO) (IEC 60079-27:2008)
EN 60079-28	Explosive atmospheres - Part 28: Protection of equipment and transmission systems using optical radiation (IEC 60079-28:2006)
EN 60079-30-1	Explosive atmospheres - Part 30-1: Electrical resistance trace heating - General and testing requirements (IEC 60079-30-1:2007)
EN 60079-31	Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t" (IEC 31/910/CD:2010)
EN 60079-5	Explosive atmospheres - Part 5: Equipment protection by powder filling "q" (IEC 60079-5:2007)

## Directives and Standards

EN 60079-6	Explosive atmospheres - Part 6: Equipment protection by oil immersion "o" (IEC 60079-6: 2007)
EN 60079-7	Explosive atmospheres - Part 7: Equipment protection by increased safety "e" (IEC 60079-7: 2006)
EN 61241-11	Electrical apparatus for use in the presence of combustible dust - Part 11: Protection by intrinsic safety "iD" (IEC 61241-11: 2005 + Corrigendum February 2006)
EN 61241-18	Electrical apparatus for use in the presence of combustible dust - Part 18: Protection by encapsulation "mD" (IEC 61241-18: 2004)
EN 61241-4	Electrical apparatus for use in the presence of combustible dust - Part 4: Type of protection "pD" (IEC 61241-4: 2001)
IEC 60061-1	Lamp caps and holders together with gauges for the control of interchangeability and safety - Part 1: Lamp caps (IEC 60061-1: 1969 + supplements A: 1970 to V: 1997 + A21: 1998 to A43: 2010 + A44: 2010, modified)
IEC 60064	Tungsten filament lamps for domestic and similar general lighting purposes - Performance requirements (IEC 60064: 1993, modified + A2: 2002, modified + A3: 2005, modified + A4: 2007, modified + A5: 2009, modified)
IEC 60079-13	Explosive atmospheres - Part 13: Equipment protection by pressurized rooms "p" (IEC 60079-13: 2010)
IEC 60081	Double-capped fluorescent lamps - Performance specifications (IEC 60081: 1997 + A1: 2000, modified + A2: 2003 + A3: 2005 + A4: 2010)
IEC 60432-1	Incandescent lamps - Safety specifications - Part 1: Tungsten filament lamps for domestic and similar general lighting purposes (IEC 60432-1: 1999, modified + A1: 2005)
IEC 60529	Degrees of protection provided by enclosures (IP Code) - Proposal on IPX9 "High pressure water test" (IEC 70/118/CD: 2009)
IEC 60947	Low-voltage switchgear and controlgear - Part 1: General rules (IEC 60947-1: 2007 + A1: 2010)
IEC TR 60079-20	Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data (IEC 60079-20-1:2010)

# Principles of Explosion-Protection

## Directives and Standards

Directive 89/391/EEC	Council Directive of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at home
Directive 1999/5/EC	Radio Equipment and Telecommunication Terminals Equipment (R&TTE)
Directive 1999/92/EC	Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres
Directive 2004/108/EC	Directive 2004/108/EC relating to electromagnetic compatibility and repealing Directive 89/336/EEC (OJ L 390 of 2004-12-31)
Directive 2006/42/EC	Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)
Directive 2006/95/EC	Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
Directive 67/548/EEC	Directive on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances
Directive 76/117/EEC	Council Directive 76/117/EEC of 18 December 1975 on the approximation of the laws of the Member States concerning electrical equipment for use in potentially explosive atmospheres
Directive 79/196/EEC	Council Directive 79/196/EEC of 6 February 1979 on the approximation of the laws of the Member States concerning electrical equipment for use in potentially explosive atmospheres employing certain types of protection
Directive 90/396/EEC	Council Directive 90/396/EEC of 29 June 1990 on the approximation of the laws of the Member States relating to appliances burning gaseous fuels
Directive 92/104/EEC	Council Directive 92/104/EEC of 3 December 1992 on the minimum requirements for improving the safety and health protection of workers in surface and underground mineral-extracting industries

## Directives and Standards

Directive 92/91/EEC

Council Directive 92/91/EEC of 3 November 1992 concerning the minimum requirements for improving the safety and health protection of workers in the mineral- extracting industries through drilling

Directive 94/9/EC

Directive 94/9/EC of the European Parliament and the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres

# Principles of Explosion-Protection

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© 2012 Cooper Crouse-Hinds GmbH  
Senator-Schwartz-Ring 26  
D-59494 Soest/Germany

Brochure No.: 300 8000 1258/6/01.12/LD  
Printed in the Federal Republic of Germany

**Cooper Crouse-Hinds GmbH**

Neuer Weg – Nord 49  
D-69412 Eberbach  
Phone +49 (0) 6271/806-500  
Fax +49 (0) 6271/806-476  
E-mail sales.CCH.de@cooperindustries.com  
Internet www.coopercrouse-hinds.eu

**MTL Instruments GmbH**

An der Gumpgesbrücke 17  
D-41564 Kaarst  
Phone +49 (0) 2131/718 93-0  
Fax +49 (0) 2131/718 93-33  
E-mail info@MTL.com  
Internet www.MTL.de

**Cooper Crouse-Hinds S.A.**

Avda. Santa Eulalia, 290  
E-08223 Terrassa  
Barcelona  
Phone +34 (0) 9-37362710  
+34 (0) 9-37835055  
E-mail sales.CCH.es@cooperindustries.com

**Cooper Crouse-Hinds (UK) Ltd.**

Building 2, Argosy Court, Whitley  
Business Park, Simitar Way  
Coventry CV3 4GA  
United Kingdom  
Phone +44 247-630-89 30  
Fax +44 247-630-10 27  
E-mail sales.CCH.gb@cooperindustries.com

**Cooper Crouse-Hinds B. V.**

Sydneystraat 74  
NL-3047 BP Rotterdam  
Phone +31 (0) 10-2452145  
Fax +31 (0) 10-2452121  
E-mail sales.CCH.nl@cooperindustries.com

**Cooper Crouse-Hinds Norge A/S**

Husebysletta 9  
N-3412-Lier  
Phone +47 32-244600  
Fax +47 32-244646  
E-mail sales.CCH.no@cooperindustries.com

**COOPER Industries Crouse-Hinds Division**

Wolf 7th North Streets  
P. O. Box 4999  
USA-Syracuse, NY 13221  
Phone +1 (0) 3-154777000  
Fax +1 (0) 3-154775717  
E-mail crouse.customerctr@  
crouse-hinds.com  
Internet www.crouse-hinds.com

**Cooper Electric (Shanghai) Co. Ltd.**

No.955 Shengli Road  
East Area of Shanghai  
Zhangjiang Hi-Tech Park  
CN - 201201 Shanghai  
Phone +86-21-2899 3600  
E-mail CCHSales@cooperindustries.com

**Cooper Crouse-Hinds Pte. Ltd.**

2 Serangoon North Avenue 5  
Fu Yu Building #06-01  
SGP - 554911 Singapore  
Phone +65 (0) 6297-4849  
Fax +65 (0) 6297-4819  
E-mail chsi-sales@cooperindustries.com  
Internet www.cchspore.com.sg/

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Cooper Industries, Ltd.  
600 Travis, Ste. 5800  
Houston, TX 77002-1001  
P: 713-209-8400  
Internet www.cooperindustries.com