

Explosion Protection Directives and Basic Principles





Note

This brochure contains general information relating to explosion protection. It was compiled with care and it takes into account the legal regulations and standards that applied at the point of going to press. Nevertheless, it is not possible to eliminate all risk of the brochure containing incorrect or misleading statements. The statements it contains cannot be used for an evaluation or a risk assessment of a specific system.

For specific applications or operating conditions, please contact the relevant technical department.

Subject to modifications

EN 2.002.1/11.17

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Explosion Protection Directives and Basic Principles

1. Introduction

In sectors such as the chemical and pharmaceutical industries, in mining, in the production of crude oil and natural gas and in the food industry (particularly in mills), flammable substances are worked with in various processing and manufacturing procedures. This means that dangerous situations continually arise that can result in explosions and jeopardise people's safety.

2. What are explosions and how are they caused?

An explosion refers to an abrupt chemical reaction that occurs between a flammable substance and oxygen, releasing large amounts of energy. This reaction results in an increase in temperature and/or pressure (expansion speed: 1 to 1,000 m/s).

Description	Expansion speed
Deflagration	0.1–1 m/s
Explosion	1–1,000 m/s
Detonation	1,000 m/s or more

Table: Deflagration, explosion, detonation

A deflagration is the weakest form of explosive combustion. It results in pressures of max. 1 bar and expansion speeds of 0.1 to 1 m/s.

Three factors need to be present simultaneously for an explosion to occur:

- A flammable substance in the form of gases, mists, vapours or dust and lint
- Oxygen (from the air)
- A source of ignition



Image: How an explosion is created

A specific ratio of flammable substance to air must be present for an explosive atmosphere to be created. If this atmosphere comes into contact with a source of ignition (e.g. a hot surface, electric spark or electric arc), the mixture will react explosively.

An atmosphere is rated as explosive on the basis of the atmospheric conditions: an explosive atmosphere has a pressure between 0.8 and 1.1 bar absolute (80 kPa to 110 kPa) and a temperature between -20 and +60 °C. The oxygen content must be roughly 21%. This standardisation is required as the safety parameters are a function of pressure, temperature and oxygen content.

3. Explosion protection

Various technical and/or organisational measures can be taken to provide protection from explosions. Measures are taken in the following order of priority:

3.1. Primary explosion protection

Primary explosion protection measures aim to prevent an explosive atmosphere from developing. Avoiding the use of flammable substances would appear to be the simplest form of explosion protection (i.e. using alternative technologies). However, in the areas of application mentioned above, this is practically impossible. It might then be possible to avoid or restrict the release of flammable substances to prevent explosive mixtures from forming, both inside and around pipe fittings. Often a more open design combined with air supply and venting is enough to provide appropriate help.

Another option is to replace or reduce the amount of oxygen in the air by systematically adding nitrogen or carbon dioxide. This is referred to as inerting. It is, of course, not possible to replace the oxygen in all areas where people are present.

3.2. Secondary explosion protection

If a hazardous explosive atmosphere cannot be prevented, secondary explosion protection measures are taken. These measures aim to stop a hazardous atmosphere from being ignited. The following ignition protection measures can be applied:

- Avoiding ignition sources
- Dividing the explosive areas up into zones
- Using explosion-proof tools and materials
- Using protection devices

All ignition protection measures taken for equipment in potentially explosive areas are part of secondary explosion protection.

3.3. Tertiary explosion protection (constructional explosion protection)

If ignition sources and thus explosion hazards pose a threat despite the above-mentioned measures being taken (e.g. as a result of electrostatic discharge or chemical reactions), the effects of an explosion or detonation must be limited to an acceptable extent. This is done by taking constructional, or tertiary, explosion protection measures.

A design that is resistant to explosion pressure is the most common constructional measure – it is not able to prevent an explosion from happening but can restrict the damage it causes. The equipment must be built to withstand the maximum explosion pressure, and in extreme cases even the detonation pressure.

In pipes and even in elongated designs, a detonation can develop in little time. If the explosion-proof design is not able to cope with the increased pressure, effective explosion-relief or pressure-relief devices need to be installed. A further measure is to use extinguishing devices to suppress an explosion.

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4. Flammable substances

Flammable substances can be gaseous, fluid or solid. They are normally rated according to their reactivity with the oxygen in the air.

4.1. Flammable gases and vapours

A flammable **gas** can sometimes be an elementary gas such as hydrogen, but flammable gases are much more often compounds that contain carbon and hydrogen. These flammable gases and vapours require only small amounts of energy to react with atmospheric oxygen.

Vapours are the parts of fluids – in the context of the explosion protection of flammable fluids – that have entered the ambient air as a result of the vapour pressure above a liquid surface, around a liquid jet or around droplets. **Mists** constitute a special form, which can be treated as vapours in terms of their explosion behaviour.

4.2. Flammable fluids

Flammable fluids are able to mix with the ambient air to form a flammable vapour/air mixture under certain conditions. Common flammable fluids are hydrocarbon compounds such as ether, acetone or petroleum spirit. The CLP Regulation classifies these fluids as **flammable**, **highly flammable** or **extremely flammable**, depending on their flash point and boiling point.

An important characteristic for flammable fluids is the **flash point**. The flash point is the lowest temperature at which a flammable fluid, under standardised test conditions, allows a sufficient quantity of vapour to be generated at its surface to enable the vapour-air mixture to be ignited by an effective ignition source. The flash point is important in the rating of potentially explosive areas. Flammable fluids with high flash point temperatures are less critical than those with a flash point at room temperature or below.

Spraying flammable fluids from spray cans or in painting facilities can create mists. Such clouds of mist are made up of very small droplets and they are able to explode. In this case, the flash point is of minor importance. The safety considerations for flammable gases apply to gases, vapours and mists consisting of flammable fluids.

Hazard category	Description of the flammable fluid	Flash point and initial boiling point
1	Extremely flammable liquid and vapour (H224)	Flash point < 23 °C Initial boiling point ≤ 35 °C
2	Highly flammable liquid and vapour (H225)	Flash point < 23 °C Initial boiling point > 35 °C
3	Flammable liquid and vapour (H226)	23 °C ≤ flash point ≤ 60 °C

Table: Classification of flammable fluids in accordance with the CLP Regulation

4.3. Flammable solids

Flammable solids in the form of dust or lint can react with atmospheric oxygen and produce disastrous explosions. Dust behaves differently depending on whether it takes the form of a dust deposit or a dust cloud. Dust deposits can ignite on hot surfaces and cause smouldering fires. Dust clouds, on the other hand, can directly result in an explosion when energy is introduced locally or on contact with hot surfaces. It normally takes more energy to trigger an explosion in mixtures with air than in gases and vapours. However, once the combustion starts, the energy released by the combustion reaction produces such high temperatures and pressures that the combustion turns into an explosion. Accordingly, smouldering layers of dust can cause a dust explosion if they are disturbed to form a dust cloud. If mechanical cleaning or incorrect extinguishing work causes dust layers to form a dust cloud, a dust explosion can be triggered. A gas or vapour explosion can also turn dust layers into a dust cloud and thus trigger a dust explosion.

In addition to the chemical characteristics of the dust, the fineness of the solid particles and their resultant overall surface area and the humidity also play a major role. The characteristics are determined by processes that take place directly on the surface of the solid.

4.4. Explosion limits

An atmosphere can only be explosive if the gaseous combustible material is present at a particular concentration. If the concentration is too high (rich mixture), the material cannot access sufficient oxygen and an explosion cannot occur. If the concentration is too low (lean mixture), the combustion cannot spread and it will come to an end. The limits within which an explosion can occur are referred to as the **upper explosion limit (UEL)** and the **lower explosion limit (LEL)**.

The limits and other characteristic data for substances are given in the GESTIS Substance Database (www.dguv.de/ifa/GESTIS/GESTIS-Stoffdatenbank/index-2.jsp).

If the ambient conditions differ from the atmospheric conditions, the explosion limits are shifted accordingly. For example, when the air contains a higher percentage of oxygen, or when pressure is higher, the upper explosion limit is greater.

In dust clouds, the average particle size is of crucial importance, in addition to the material characteristics. Greater fineness increases the total surface area of the dust that is able to react with oxygen.

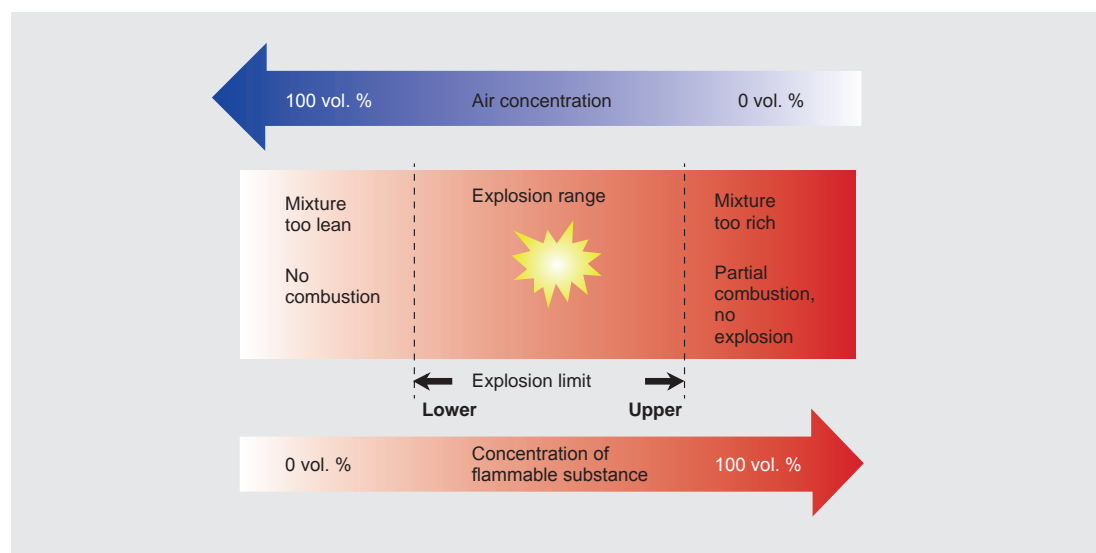


Image: Explosion range

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Gases/vapours	LEL	UEL
Hydrogen	4.0 %	77.0 %
Methane	4.4 %	17.0 %
Acetylene	2.3 %	100.0 %
Propane	1.7 %	10.8 %
Carbon disulphide	0.6 %	60.0 %
Hydrogen sulphide	4.3 %	45.5 %
Ammonia	15.4 %	33.6 %
Diesel fuel	0.6 %	6.5 %
Petrol	0.6 %	8.0 %
Ethanol	3.1 %	27.7 %
Carbon monoxide	11.3 %	75.6 %

Table: Concentrations of flammable substances

4.5. Maximum experimental safe gap (MESG)

The **maximum experimental safe gap (MESG)** is a measurement of how easily a hot flame will pass through a narrow gap. It is determined by igniting a gas mixture in a test apparatus and determining how wide a 25 mm-long gap needs to be for flames to be able to pass through it.

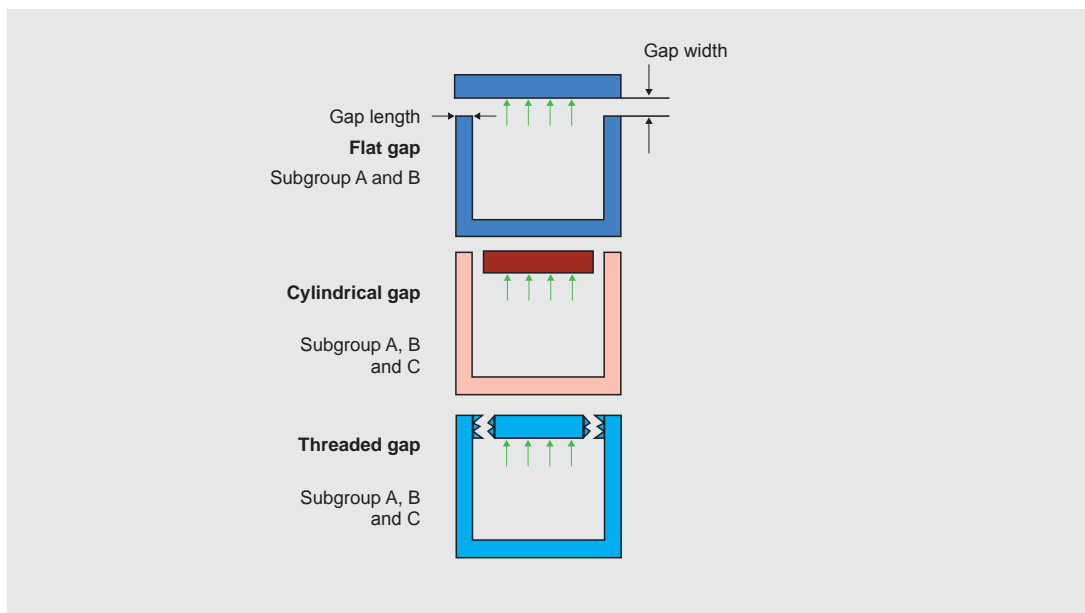


Image: Gap variants

4.6. Minimum ignition energy, minimum ignition current

For an explosive mixture to ignite, a minimum ignition energy must be present, created by a spark. The spark produces a very high temperature locally, the explosive atmosphere starts to combust and the energy this releases causes an explosion. The **minimum ignition current (MIC)** is the minimum amount of current in a circuit that is required for an explosive mixture to ignite, regardless of its composition, relative to the minimum current required to ignite a methane gas mixture.

4.7. Groups

The explosive substances are divided up into groups on the basis of their MESG and MIC values. Gases belong to **Group II**, with subgroup A the least dangerous and subgroup C the most.

Group/subgroup	Maximum experimental safe gap	Minimum ignition current, relative
II A	> 0.9 mm	> 0.8
II B	$0.5 < x < 0.9$ mm	$0.45 < y < 0.8$
II C	< 0.5 mm	< 0.45

Table: Groups

Dusts are classified in the separate **Group III**.

This group also contains subgroups:

- IIIA: flammable lint
- IIIB: non-conductive dusts
- IIIC: conductive dusts

These subgroups have not been directly adopted in the ATEX directives. This marking applies, however, in conjunction with the harmonised standards EN 60079 and EN 80079.

Although the term “explosion group” was once used widely, it is no longer used in the latest industrial standards. The more general term “group” is now used instead.

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5. Temperature classes

To assess the ignition risk of individual substances with greater precision, their ignition temperature must be considered. Various factors need to be taken into account, such as the form, size, type and characteristics of the contact surface.

The maximum occurring surface temperature must always be lower than the ignition temperature.

5.1. Gases/vapours

For gases and vapours, the specific ignition temperature is determined in accordance with **EN 60079-20-1 - Material characteristics for gas and vapour classification.**

Gases and vapours are classified by temperature class accordingly.

Temperature class	Ignition temperature range of mixture	Permissible surface temperature of equipment
T1	> 450 °C	450 °C
T2	> 300 to < 450 °C	300 °C
T3	> 200 to < 300 °C	200 °C
T4	> 135 to < 200 °C	135 °C
T5	> 100 to < 135 °C	100 °C
T6	> 85 to < 100 °C	85 °C

Table: Temperature classes

	II A	II B	II C
T1	Methane Ammonia Carbon monoxide		Hydrogen
T2	Propane Petrol	Ethanol	Acetylene
T3	Diesel	Hydrogen sulphide	
T4	Acetaldehyde		
T5			
T6			Carbon disulphide

Table: Classification of gases and vapours

If operation will result in the gas being heated to the temperature of the surrounding surfaces, the surface temperature must not exceed 80 % of the ignition temperature of the gas mixture. The surface temperature can rise to the ignition temperature of the gas if the explosive atmosphere only occurs briefly or rarely in normal operation.

5.2. Dusts

Flammable dusts, unlike gases and vapours, are not classified in temperature classes. There is, however, a standardised system for calculating their critical surface temperature. This calculation method is set down in **EN 80079-20-2 - Explosive atmospheres: Material characteristics - Combustible dusts test methods** and in **EN 50281-2-1 - Test methods; methods for determining the minimum ignition temperatures of dust** for dust layers < 5 mm.

Dust can be suspended in the air in the form of a dust cloud or deposited on a surface as a dust layer. The ignition temperature of a dust cloud may be significantly different from that of a dust layer. There are different values for the two parameters. To determine the maximum permissible surface temperature, safety factors need to be taken into account. For a standardised dust layer with a thickness of 5 mm, there must be a difference of 75 K between the ignition temperature and the permissible surface temperature. For a dust cloud, the surface temperature must not exceed 2/3 of the ignition temperature. The lower of these two temperatures must then be taken into account when devices are being selected.

The ignition temperatures of dusts and other specific characteristics are given in the **GESTIS dust database** provided by Germany's Institute for Occupational Safety and Health (<http://staubex.ifa.dguv.de/explosuche.aspx?lang=e>).

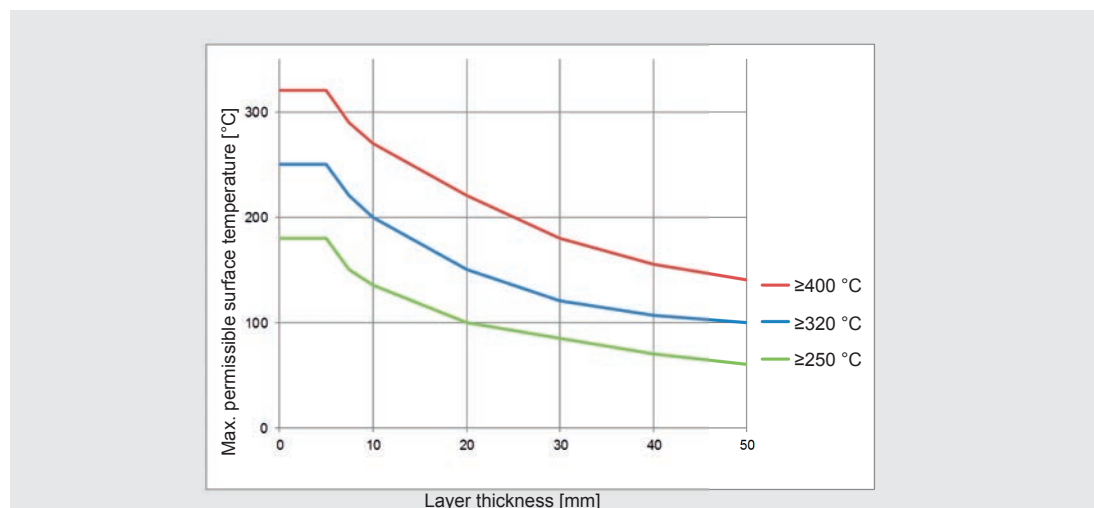
Ignition temperature of dusts	
Dust layer: permissible surface temperature $T_{L \text{ perm.}} = T_{L \text{ min.}} - 75 \text{ K}$	Dust cloud: permissible surface temperature $T_{C \text{ perm.}} = 2/3 T_{C \text{ min.}}$
Max. permissible surface temperature of device $T_{L \text{ perm.}} \geq T_{\text{perm.}} \leq T_{C \text{ perm.}}$	

Table: Ignition temperature of dusts

Dust layers greater than 5 mm

The temperature characteristics determined according to EN 80079-20-2 only apply for dust layers with a thickness of 5 mm or below. The thermal insulation increases in layers with greater thicknesses. This means that the device's max. permissible surface temperature needs to be reduced further.

The temperature is derived from the graph given in **EN 60079-14 - Electrical installations design, selection and erection**. For layer thicknesses exceeding 50 mm, the ignition temperature needs to be determined in laboratory tests. This also applies to all layer thicknesses exceeding 5 mm where the ignition temperature for a 5 mm thickness is less than 250 °C. Laboratory tests are also needed if the equipment is fully covered by a layer of flammable dust.



Determining the max. surface temperature for dust layers >5 mm

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6. Ignition sources

To prevent an explosion effectively, it is first necessary to identify what types of ignition sources are possible and which ones apply for the particular equipment.

EN 1127 - Explosive atmospheres provides an overview of possible ignition sources.

6.1. Hot surfaces

In some cases, the temperature of a surface alone is enough to ignite an explosive atmosphere. The critical temperature is dependent on a variety of factors. For example, the form and the size of the heated element, the concentration gradient in the wall area and to some extent even the wall material all play a role.

Hot surfaces such as radiators, drying cabinets and heating coils are easy to identify. But mechanical procedures and cutting processes can also create hazardous surface temperatures. The same applies to devices and components that convert mechanical energy into heat, such as friction clutches and mechanical brakes. Moving parts in bearings, shaft feed-throughs and sleeves can also become ignition sources if they have insufficient lubrication. Dirt or foreign bodies entering the device can create high temperatures almost immediately in some cases.

6.2. Flames, hot gases and particles

Flames, even in their smallest form, are one of the most effective sources of ignition. Flames generally occur in combustion engines and in analysis instruments, and at their gas outlet points. Even if there is an explosive atmosphere outside the device – in adjacent parts of the system – flames can pass through openings such as bleed lines, or hot gases and particles can be blown into these areas and cause an ignition.

6.3. Mechanically generated sparks

Mechanically generated sparks are created when particles at an elevated temperature become detached from solid materials as a result of friction, impact or grinding. If these particles consist of oxidising substances such as iron or steel, they can reach temperatures far exceeding 1,000 °C as a result of the oxidation process, creating an ignition.

Sparks can also be created by foreign bodies such as stones and metal particles entering rotating devices and components.

Impact involving rust or light metals such as aluminium and magnesium, or alloys of these two metals, can generate a thermite reaction with very high temperatures.

6.4. Electrical apparatus

In electrical equipment such as I&EC devices (instrumentation and control engineering devices) and motors, electrical sparks (such as those caused by electrical circuits opening or closing, loose connections or compensating currents) can function as ignition sources even at low voltages.

6.5. Stray electric currents, cathodic corrosion protection

Disconnecting, connecting or bypassing systems or system parts in which compensating currents can occur can create electrical sparks even at low potential differences. Even if no sparks occur, current paths may heat up to critical levels.

The above-mentioned ignition hazards can also be expected when cathodic corrosion protection is used with an external power supply. If sacrificial anodes are used, however, ignition hazards resulting from spark formation are not generally to be expected.

6.6. Static electricity

Unlike discharge in the case of stray electric currents, a discharge resulting from static electricity can occur even if no voltage source is present. This means that there is a risk of spark formation resulting from static discharge even in non-electrical systems and system parts. Plastics made from non-conductive materials can become charged.

Separating processes such as a film passing over a roller or hydraulic oil flowing over filter elements can result in discharge and sparks.

6.7. Lightning

Because of the large amount of energy involved, lightning always causes an explosive atmosphere to ignite. Strong currents fly in all directions around the impact point that can cause ignitable sparks and fire sprays in the adjacent areas. The currents that occur can also create intense heating of the lightning's discharge channels.

6.8. High-frequency electromagnetic waves (radio waves, microwaves; frequency: 10^4 Hz– $3 \cdot 10^{11}$ Hz)

Systems that release high-frequency electromagnetic waves are for example high-frequency generators for heating, drying, curing and welding. Conductive parts in this type of radiation field act as receivers and can ignite an explosive atmosphere under certain conditions. This can cause thin wires to glow with heat.

6.9. Electromagnetic waves (infrared to UV radiation; frequency: $3 \cdot 10^{11}$ Hz– $3 \cdot 10^{15}$ Hz)

Radiation in this spectral range can become a source of ignition, especially when focused, or start a fire on solid surfaces as a result of absorption. In laser radiation in particular, the power density can be sufficient to cause ignition even from a great distance. Sunlight can trigger an ignition if the radiation is concentrated by objects such as bottles or concave mirrors.

In some cases, the radiation from strong light sources can be absorbed by dust particles so greatly that the particles become ignition sources.

6.10. Ionising radiation

Ionising radiation caused by X-ray tubes or radioactive substances can ignite an explosive atmosphere as a result of energy absorption. However, the radiation source can also heat up enough to be considered an ignition source itself.

Ionising radiation can also cause chemical mixtures to decompose and reactive radicals or chemically volatile compounds to be released. This can result in ignition.

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6.11. Ultrasound

When ultrasound is applied, the treated substance absorbs the energy, which can cause it to heat up enough to generate an ignition.

6.12. Adiabatic compression, shock waves, flowing gases

An abrupt compression of a shock wave can cause an increase in temperature. This temperature increase can be large enough to cause an explosive atmosphere to ignite.

Flowing gases can cause a temperature increase that can lead to ignition when high-pressure gases in the pipe system are suddenly depressurised at narrow points, bends or closed gate valves, causing shock waves to be diffracted or reflected.

6.13. Exothermic reactions

Certain unstable substances tend to chemically react even at room temperature. This releases heat, which is normally directly transferred to the surrounding area without causing any increase in the substance's temperature. If anything prevents this energy transfer from being completed in full, the substance can self-ignite. This can also happen if the substance is stored at an excess temperature. These substances can be either gas mixtures or dusts (oxidation).

7. Classification and categorisation of equipment for explosive atmospheres

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

7.1. Equipment groups as defined by 2014/34/EU

Equipment group I

Equipment group I only includes equipment intended for use in underground parts of mines, and in those parts of surface installations of such mines, liable to be endangered by firedamp and/or combustible dust. EU Directive 2014/34/EU divides this group up into the equipment categories **M1** and **M2**.

The **M** stands for **mining** and the number signifies the safety level. **M1** indicates a **very high** level of safety. This means that operation of the equipment can continue in an explosive atmosphere even if equipment disturbances occur rarely. If one means of protection fails, a second independent means of protection then provides the required level of safety. Furthermore, safety is still assured if two faults occur independently of each other. **M2** indicates a **high** level of safety. The equipment assures safety in normal operation under the severe operating conditions in mining. In the event of an explosive atmosphere occurring, this equipment is switched off securely.

Equipment group II

Equipment in equipment group II can be used in all areas (apart from mining) in which an explosive atmosphere constituting a mixture of air and gases, vapours or mists and/or air/dust mixtures is to be expected.

7.2. Equipment categories

Devices of equipment group II are classified into one of the 3 equipment categories, based on the frequency and duration of an explosive atmosphere and the required level of safety.

- **Equipment category 1**

Areas of application for this category are areas in which an explosive atmosphere constituting a mixture of air and gases, vapours or mists or air/dust mixtures is present continuously or for long periods or frequently. This equipment provides a very high level of safety even in the case of rare equipment disturbances. As is the case for category M1, if one means of protection fails, a second independent means of protection must be present, and if two faults occur independently of each other the required level of safety must still be provided.

- **Equipment category 2**

Equipment in this category is intended for use in areas in which an explosive atmosphere comprised of gases, vapours, mists or dust/air mixtures can be expected to occur occasionally. This equipment provides a high level of safety in normal operation and in the event of frequent disturbances and foreseeable faults.

- **Equipment category 3**

Equipment in category 3 is intended for use in areas in which an explosive atmosphere comprised of gases, vapours, mists or dust clouds is not to be expected, or, if such an atmosphere does occur, it is likely to do so only infrequently and for a short period. Equipment in this category provides the required level of safety in normal operation.

7.3. Types of explosive atmosphere

Explosive atmospheres are divided up into atmospheres caused by gas and atmospheres caused by dust. Accordingly, the letters **G** and **D** are used for marking. Fluids do not pose an explosion hazard in themselves, but the vapour/air mixtures that form at their surfaces do. Areas containing hazardous fluids are therefore always treated as gas-based atmospheres.

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7.4. Zone divisions as defined by directive 1999/92/EC

This directive defines explosive areas as particular zones according to the frequency and duration of an explosive atmosphere. Equipment can be designed in accordance with the particular zones. This approach makes sense from an economic perspective, without neglecting the issue of safety.

- **Zone 0 (gas)**
Location in which an explosive atmosphere consisting of a mixture with air and flammable gases, vapours or mists is present continuously, or for long periods or frequently. This only includes small areas in workplaces that are mostly inaccessible or internal parts of technological systems.
- **Zone 1 (gas)**
Location in which an explosive atmosphere consisting of a mixture with air and flammable gases, vapours or mist is likely to occur in normal operation occasionally. This zone includes the close surroundings of zone 0. The precise limits must be defined in accordance with the particular hazardous substance and the ambient conditions.
- **Zone 2 (gas)**
Location in which an explosive atmosphere consisting of a mixture with air and flammable gases, vapours or mist is not likely to occur in normal operation, but if it does occur, will persist for a short period only.

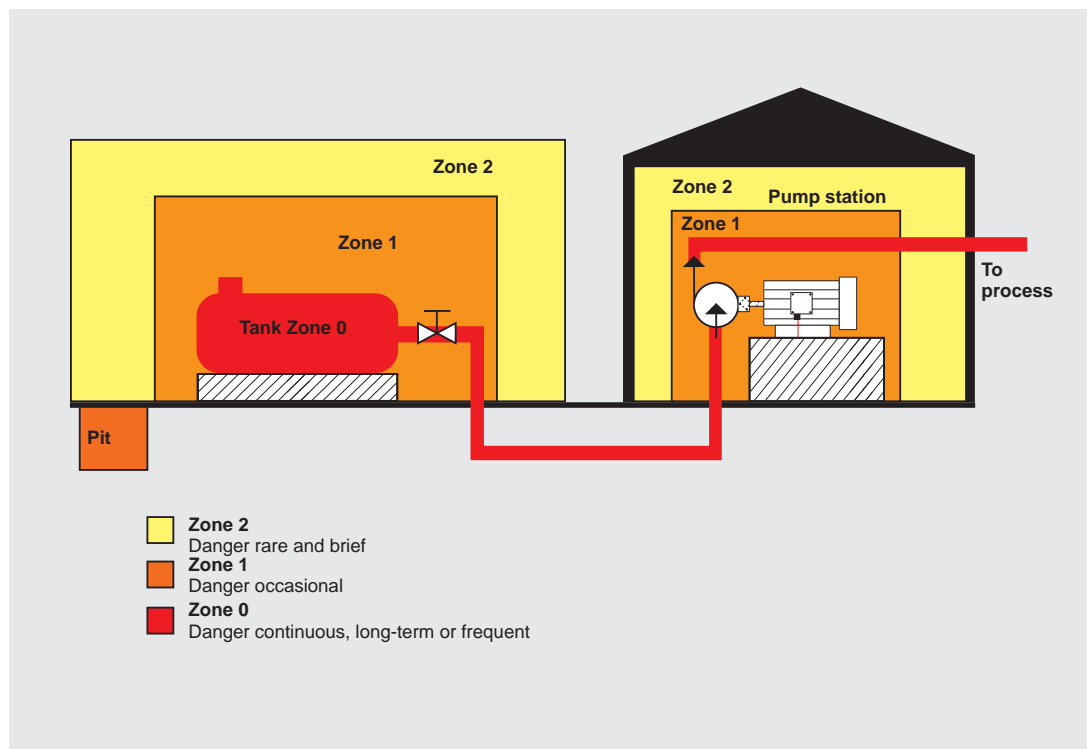


Image: Zone divisions for gases

- **Zone 20 (dust)**

Location in which an explosive atmosphere in the form of a cloud or layer of combustible dust in air is present continuously, or for long periods or frequently. This only includes small areas in workplaces that are mostly inaccessible or internal parts of technological systems.

- **Zone 21 (dust)**

Location in which an explosive atmosphere in the form of a cloud or layer of combustible dust is likely to occur in normal operation occasionally. This zone includes areas that contain dust deposits large enough for dust clouds to occur occasionally in normal operation.

- **Zone 22 (dust)**

Location in which an explosive atmosphere in the form of a cloud or layer of combustible dust in air is not likely to occur, but if it does occur, will persist for a short period only (e.g. in the case of disruptions). Dust deposits in these areas must be removed regularly.

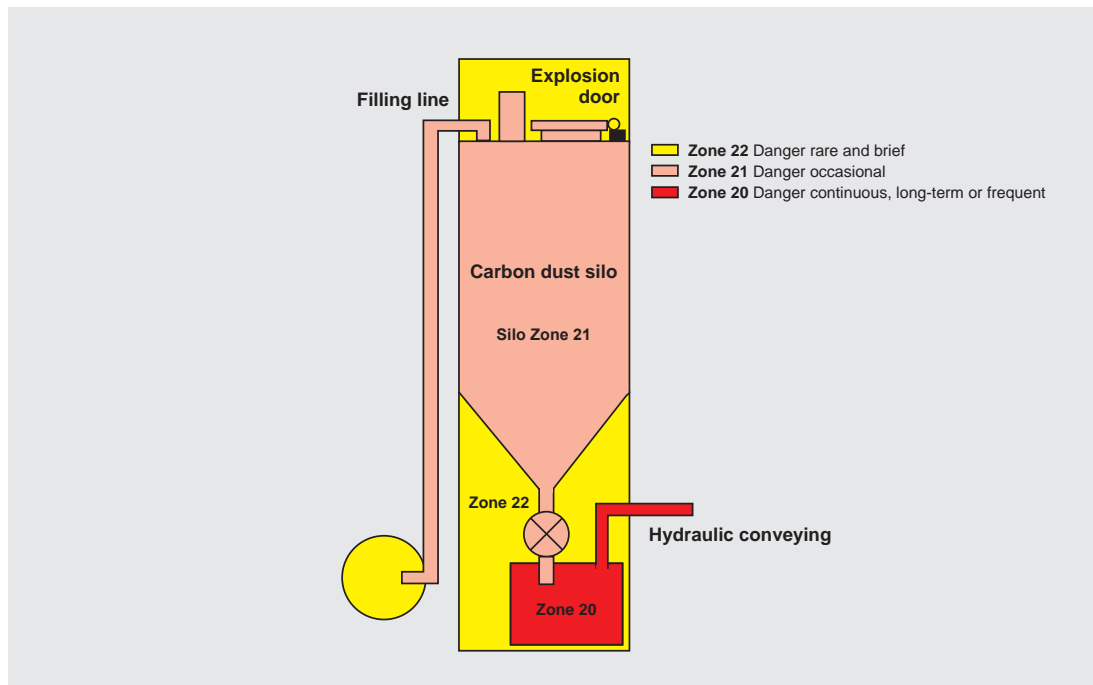


Image: Zone divisions for dusts

The terms “continuously”, “occasionally”, “long periods” and “short periods” are not defined precisely in these directives. Reference values for classification are given in the table below.

Zone	Frequency of occurrence of mixtures		Period (duration)
	Annually	Day/month/year	
0 20	> 1,000 times	> 3 times/day	> 10 h
1 21	> 10 times < 1,000 times	> 1 time/month < 3 times/day	> 30 min
2 22	> 1 time < 10 times	> 1 time/year < 1 time/month	< 30 min

Table: Frequency of occurrence of mixtures

Explosion Protection Directives and Basic Principles

7.5. Criteria for the selection of equipment and protective systems

If the explosion protection document based on a risk assessment does not state otherwise, equipment and protective systems for all places in which explosive atmospheres may occur must be selected on the basis of the categories set out in Directive 2014/34/EU.

For the individual zones, equipment can be used as shown in the table below, provided they are suitable for gases, vapours or mists and/or dusts:

Zone	Equipment category
0 20	1
1 21	1 or 2
2 22	1, 2 or 3

Table: Zones – equipment categories

8. Equipment protection level

As an alternative to the categorisation of explosion-protected devices defined by EU Directive 2014/34/EU, the concept of **equipment protection level (EPL)** has been introduced at an international level.

It uses the divisions **M (mining)**, **G (gas)** and **D (dust)**, in accordance with the particular explosive atmosphere. The letter **a**, **b** or **c** is added to indicate the level of protection. Only two protection levels apply for mining: **a** and **b**. The relationship between the equipment protection level and the categories of the ATEX Directive is shown in the following table:

Equipment protection level EPL	ATEX Directive 2014/34/EU category	ATEX Directive 99/92/EC zone	Protection provided
Ma	I M1	-	Very high
Mb	I M2	-	High
Ga	II 1G	0	Very high
Gb	II 2G	1	High
Gc	II 3G	2	Normal
Da	II 1D	20	Very high
Db	II 2D	21	High
Dc	II 3D	22	Normal

Table: Equipment protection level EPL

The standard EN 60079-14 specifies particular ignition protection types for each EPL. The protection levels a, b and c are also used for some of the ignition protection types (e.g. ignition protection type “intrinsic safety” – ia, ib, ic – see also section 9).

9. Types of ignition protection

If all measures to prevent an explosive atmosphere from occurring have been taken and an explosive atmosphere nevertheless occurs, only explosion-protected equipment may be used for the affected area.

Electrical equipment can be divided up into various ignition protection types as defined in the construction provisions of the series of standards **EN 60079 - Explosive atmospheres**.

Zone	EPL	Ignition protection type	Code	Standards
0	Ga	Flameproof enclosure	da	EN 60079-1
		Intrinsic safety	ia	EN 60079-11
		Encapsulation	ma	EN 60079-18
		Two independent ignition protection types that both fulfil EPL Gb	-	EN 60079-26
		Protection of equipment and transmission systems using optical radiation	op is	EN 60079-28
1	Gb	Flameproof enclosure	db	EN 60079-1
		Increased safety	eb	EN 60079-7
		Intrinsic safety	ib	EN 60079-11
		Encapsulation	mb	EN 60079-18
		Liquid immersion	ob	EN 60079-6
		Pressurised enclosure	pxb pyb	EN 60079-2
		Powder filling	q	EN 60079-5
		Protection of equipment and transmission systems using optical radiation	op is op sh op pr	EN 60079-28
2	Gc	Flameproof enclosure	dc	EN 60079-1
		Intrinsic safety	ic	EN 60079-11
		Encapsulation	mc	EN 60079-18
		Liquid immersion	oc	EN 60079-6
		Non-sparking	nA	EN 60079-15
		Restricted breathing	nR	EN 60079-15
		Non-incendive	nC	EN 60079-15
		Increased safety	ec	EN 60079-7
		Pressurised enclosure	pzc	EN 60079-2
		Protection of equipment and transmission systems using optical radiation	op is op sh op pr	EN 60079-28

Table: Electrical ignition protection types for gas – protection provided

Explosion Protection Directives and Basic Principles

Zone	EPL	Ignition protection type	Code	Standards
20	Da	Intrinsic safety	ia	EN 60079-11
		Encapsulation	ma	EN 60079-18
		Protection by enclosure	ta	EN 60079-31
21	Db	Intrinsic safety	ib	EN 60079-11
		Encapsulation	mb	EN 60079-18
		Protection by enclosure	tb	EN 60079-31
		Pressurised enclosure	pxb, pyb	EN 60079-2
22	Dc	Intrinsic safety	ic	EN 60079-11
		Encapsulation	mc	EN 60079-18
		Protection by enclosure	tc	EN 60079-31
		Pressurised enclosure	pzc	EN 60079-2


Table: Electrical ignition protection types for dust – protection provided

Non-electrical devices are primarily described by the international standards **EN 80079-36** and **EN 80079-37 - Non-electrical equipment for explosive atmospheres**. The previous standard parts for constructional safety "c", control of ignition sources "b" and liquid immersion "k" were combined in standard EN 80079-37. In addition, a few standards from the EN 13463 series apply.

Zone	EPL	Ignition protection type	Code	Standards
0 20	Ga Da	Constructional safety	c	EN 80079-37
		Liquid immersion	k	
		Control of ignition source	b	
1 21	Gb Db	Constructional safety	c	EN 80079-37
		Liquid immersion	k	
		Control of ignition source	b	
		Flameproof enclosure	d	EN 13463-3
		Pressurised enclosure	p	EN 60079-2
2 22	Gc Dc	Constructional safety	c	EN 80079-37
		Liquid immersion	k	
		Control of ignition source	b	
		Flameproof enclosure	d	EN 13463-3
		Pressurised enclosure	p	EN 60079-2
		Flow restricting enclosure	fr	EN 13463-2

Table: Non-electrical ignition protection types - protection provided

9.1. Flameproof enclosure, electrical ignition protection

	Standard:	EN 60079-1 - Equipment protection by flameproof enclosures "d"
	Code:	da, db, dc
	Area of application:	Zone 0, 1, 2

- **Principle:**

Parts that could ignite a potentially explosive atmosphere are located inside an enclosure which can withstand the pressure of an explosion of the explosive mixture inside, and prevent the transmission of the explosion to the explosive atmosphere surrounding the enclosure. This principle allows an explosive atmosphere to penetrate into the housing of the equipment. If an explosion occurs inside the housing, this explosion must not be transferred to the surrounding area. Any gaps present in the housing must therefore be designed, in terms of their geometry and length, to securely prevent ignition outside of the housing. The explosion pressure that develops inside the housing must be securely controlled by the housing.

- **Applications:**

Equipment that produces sparks or electric arcs and/or hot parts during operation.
Switching devices and switching systems, command and display units, controls, motors, transformers, heating devices, lights
Solenoid valves, proportional and servo valves

9.2. Pressurised enclosure

	Standard:	EN 60079-2 - Equipment protection by pressurized enclosure "p"
	Code:	pxb, pyb, pzc
	Area of application:	Zone 1, 2, 21, 22

- **Principle:**

An explosive atmosphere is prevented from developing inside the equipment by an ignition protection gas inside the enclosure being kept at a higher pressure than that of the surrounding atmosphere.


The ignition protection is divided up into three ignition protection types (px, py and pz), depending on the required equipment protection level (Gb or Gc) and on whether the housing contains any ignitable equipment. For use in zone 2 or 22, the over-pressure provided by the protective gas must be at least 25 Pa for the ignition protection type pz. For the ignition protection types px and py for use in zone 1 or 21, the over-pressure must be at least 50 Pa. Before start-up, the housing and all the corresponding pipes must be flushed thoroughly. During operation, the over-pressure must be monitored and if it drops, a warning must be issued or the device must be shut down. Conditioned dried compressed air is normally used as the protective gas. Nitrogen or CO₂ can also be used as an alternative.

- **Applications:**

Equipment that produces sparks or electric arcs and/or hot parts during operation.
Switchgear and control cabinets, analysis instruments, large motors

Explosion Protection Directives and Basic Principles

9.3. Powder filling

	Standard:	EN 60079-5 - Equipment protection by powder filling "q"
	Code:	q
	Area of application:	Zone 1, 2

- **Principle:**


The housing is filled with a finely grained filling material to prevent an electric arc that develops inside the housing from igniting an explosive atmosphere surrounding the housing when the equipment is used as intended. There must be no risk of ignition by flames, or by increased temperatures, at the surface of the enclosure.

The housing is filled with quartz sand or else with glass balls. The grain size, purity, residual moisture and dielectric strength must meet particular criteria. The housings must be filled, closed up and sealed during manufacture. It must not be possible to open them without leaving visible signs; after repair work, the housings must be sealed and labelled again.
- **Applications:**

Components that produce sparks or hot parts that can function perfectly when filled with a finely grained filling material.

Sensors, display units, electronic ballasts, transmitters

9.4. Liquid immersion, electrical ignition protection

	Standard:	EN 60079-6 - Equipment protection by liquid immersion "o"
	Code:	ob, oc
	Area of application:	Zone 1, 2


- **Principle:**

Parts that could cause an explosive atmosphere to ignite are immersed in a protective fluid such that an explosive atmosphere above the surface of the liquid or outside the encapsulated area cannot be ignited.

Components that constitute an ignition source are immersed in the protective fluid deeply enough to prevent ignition spreading to the area above the surface of the fluid. The fluid level must be monitored. It must be ensured that the protective fluid does not heat up to prohibited levels. The fluid quality must be monitored as its characteristics could change as a result of time deterioration or electric arc or sparks could cause it to decompose.
- **Applications:**

Transformers, starting resistors

9.5. Increased safety

	Standard:	EN 60079-7 - Equipment protection by increased safety "e"
	Code:	eb, ec
	Area of application:	Zone 1, 2

- **Principle:**

Additional measures are taken to achieve an increased level of safety such that excess temperatures and the formation of sparks or electric arcs in the internal and external parts of equipment cannot occur during normal operation.

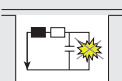
Electrical connections must be designed to prevent the supply lines from becoming released from the intended position during clamping and they must be secured against becoming loose. The contact pressure must also be maintained in the long term under the foreseen temperature changes. As there is some risk of an explosive gas mixture penetrating, all surfaces inside the housing must also be prevented from reaching excess temperatures. The housing undergoes a mechanical impact test and minimum requirements for the IP protection class apply in accordance with how the housing is used.

The requirements from the ignition protection type "nA" (EN 60079-15) were transferred to this standard and are now marked as "ec".

- **Applications:**

Terminals and terminal boxes, control boxes for installing Ex components, squirrel cage motors, lights
Solenoid valves, proportional and servo valves

9.6. Intrinsic safety

	Standard:	EN 60079-11 - Equipment protection by intrinsic safety "i"
	Code:	ia, ib, ic
	Area of application:	Zone 0, 1, 2, 20, 21, 22

- **Principle:**

Intrinsically safe electrical equipment contains only circuits which meet the requirements of intrinsically safe circuits. A circuit is intrinsically safe if none of the sparks or thermal effects that occur under the test conditions specified in the standard could cause an explosive atmosphere to ignite. The test conditions cover both normal operation and certain fault conditions.

The equipment is divided up into the subgroups ia, ib and ic depending on the zone in which it is to be used. All construction elements are configured in terms of their voltage and current to ensure that the energy content of the circuit is not normally sufficient to ignite an explosive mixture. Energy storage devices such as capacitors are only permissible in intrinsically safe circuits to a very limited degree.


If several intrinsically safe pieces of equipment are interconnected, it must be checked that all the construction elements as a whole still meet the criteria for intrinsic safety. The corresponding specifications are given in EN 60079-25.

- **Applications:**

Measuring, monitoring and information devices, sensors and visual or acoustic actuators
Solenoid valves, servo valves

Explosion Protection Directives and Basic Principles

9.7. Ignition protection type “n_”

	Standard:	EN 60079-15 - Equipment protection by type of protection “n”
	Code:	nA, nC, nR
	Area of application:	Zone 2

- **Principle:**

Electrical equipment is not able to ignite a surrounding explosive atmosphere in normal operation and under certain abnormal operating conditions.

- **nA: non-sparking equipment**

The design reliably prevents the formation of excess temperatures and sparks or electric arcs in normal operation.

- **nC: sealed device**

The design prevents an external explosive atmosphere from entering. The device cannot be opened in normal operation. It must not be possible for elastic seals to become damaged under normal operating conditions.

- **nC: hermetically sealed device**

The design prevents an external explosive atmosphere from entering. The seal is created by a melting process such as soldering or welding.

- **nC: non-incendive equipment**

Component with contacts that close or open a circuit that may cause ignition. The contact mechanism is designed to prevent an explosive mixture from igniting.

- **nC: encapsulated device**

An encapsulation, such as a sealing compound, prevents the external atmosphere from entering the component. The device cannot be opened in normal operation.


- **nR: restricted breathing**

The housing is designed to limit the penetration of gases, vapours and mists. The seal can be provided by encapsulated seals or elastic seals. After installation and maintenance, it must be possible to check the impermeability. In terms of its power dissipation, the equipment must be designed to prevent the surface temperature measured on the outside from exceeding the permissible temperature class. If the component contains parts that produce sparks, the temperature increase must not exceed 10 K in comparison with the ambient temperature.

- **Applications:**


Installation material, terminal compartments, lights, cells and batteries, transformers, contact systems, coils of solenoid valves or motors, complete circuit boards, spark-generating equipment, switching devices, measuring, monitoring and information systems

9.8. Encapsulation

	Standard:	EN 60079-18 - Equipment protection by encapsulation "m"
	Code:	ma, mb, mc
	Area of application:	Zone 0, 1, 2, 20, 21, 22

- **Principle:**
Parts that could ignite an explosive atmosphere by sparks or heating are embedded in a casting compound such that the explosive atmosphere cannot be ignited. Duromers, thermoplastics, elastomers with or without filler materials and other additives can be used as casting compound. The compound must be resistant to electrical, thermal, mechanical and chemical influences.
- **Applications:**
Relays, signalling and command devices, solenoid valves, motors


9.9. Optical radiation

	Standard:	EN 60079-28 - Protection of equipment and transmission systems using optical radiation
	Code:	op is, op pr, op sh
	Area of application:	Zone 0, 1, 2

- **Principle:**
Appropriate measures are taken to prevent optical radiation from igniting an explosive atmosphere.
 - **op is: inherently safe optical radiation**
Under normal conditions and certain fault conditions, visible radiation or infrared radiation cannot supply enough energy to ignite an explosive atmosphere. In this protection class, fibre optical cables can be disconnected and connected during operation.
 - **op pr: protected optical radiation**
The radiation is enclosed in an optical fibre or other transmission medium. Fibre optic cables must be configured with corresponding strength. Equipment must be designed to prevent a hazardous amount of light energy from escaping.
 - **op sh: optical radiation with interlock**
This protection class involves interlock shut-off devices that securely stop the optical radiation in the event of a fault.
- **Applications:**
Fibre optic cables, lamps, lasers, LEDs

Explosion Protection Directives and Basic Principles

9.10. Protection by enclosure

	Standard:	EN 60079-31 - Equipment dust ignition protection by enclosure "t"
	Code:	ta, tb, tc
	Area of application:	Zone 20, 21, 22


- **Principle:**
The housing is impermeable such that dust penetration is prevented (IP6X) or reduced to a non-hazardous level (IP5X). The temperature of the housing must not be able to ignite the surrounding atmosphere. It is essential that perfect impermeability is provided. The inspection must therefore also include a pressure test. This ensures that any pressure differences that may occur between the inside and outside, for example as a result of temperature fluctuations, do not have any negative effects on the seals.
- **Applications:**
Switching devices and switching systems, control, connection and terminal boxes, motors, lights
Solenoid valves, proportional and servo valves, measuring and monitoring devices

9.11. Flow restricting enclosure

	Standard:	EN 13463-2 - Protection by flow restricting enclosure "fr"
	Code:	fr
	Area of application:	Zone 2, 22

- **Principle:**
The impermeability of the housing prevents a hazardous atmosphere from entering such that no explosive atmosphere can occur inside the housing. Pressure differences between the inner and outer atmosphere, such as those caused by temperature changes, must be taken into account.
- **Applications:**
Switching devices, complex machines, large machines

9.12. Flameproof enclosure, non-electrical ignition protection

	Standard:	EN 13463-3 - Protection by flameproof enclosure "d"
	Code:	d
	Area of application:	Zone 1, 2, 21, 22


- **Principle:**

Parts that could ignite a potentially explosive atmosphere are located inside an enclosure which can withstand the pressure of an explosion of the explosive mixture inside, and prevent the transmission of the explosion to the explosive atmosphere surrounding the enclosure. This principle allows an explosive atmosphere to penetrate into the housing of the equipment. If an explosion occurs inside the housing, this explosion must not be transferred to the surrounding area. Any gaps present in the housing must therefore be designed, in terms of their geometry and length, to securely prevent ignition outside of the housing. The explosion pressure that develops inside the housing must be securely controlled by the housing. The design requirements for non-electrical devices specified by this standard, EN 13463-3, are largely identical to the requirements set down by the standard EN 60079-1 for electrical devices.

- **Applications:**

Brakes, friction clutches, catalytic converters

9.13. Constructional safety

	Standard:	EN 80079-37 - Protection by constructional safety "c"
	Code:	h
	Area of application:	0, 1, 2, 20, 21, 22

- **Principle:**


Established technical principles are applied to reduce to a very low level the risk of mechanical faults that could result in temperatures or sparks capable of causing ignition. The components must be configured such that there is no risk of heating as a result of friction, for example. The components must also not cause electrostatic charging or friction sparks.

- **Applications:**

Couplings, pumps, gear drives, chain drives, conveyor belts, pressure and flow-control valves, cylinders, directional valves

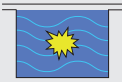
Explosion Protection Directives and Basic Principles

9.14. Control of ignition source

	Standard:	EN 80079-37 - Protection by control of ignition source “b”
	Code:	h
	Area of application:	Zone 0, 1, 2, 20, 21, 22

- **Principle:**
In non-electrical devices, which do not show an effective source of ignition during normal operation, a fault can result in a potential source of ignition. For this reason, often sensors are fitted to the devices, which monitor the proper functioning and trigger the required measures as specified by the operating parameters in case of deviations.
For the protection class, the entire ignition protection system, consisting of a sensor, evaluation unit and an output device, must be subjected to an assessment of reliability. The functional safety standards EN 13849 or EN 61508 can be referred to for this.
- **Applications:**
Bearings, pumps, agitators, fans, vacuum pumps

9.15. Liquid immersion, non-electrical ignition protection

	Standard:	EN 80079-37 - Protection by liquid immersion “k”
	Code:	h
	Area of application:	Zone 0, 1, 2, 20, 21, 22

- **Principle:**
Non-electrical devices of this ignition protection type have potential ignition sources that are rendered ineffective either by immersion in a protective fluid or by constant wetting with a protective fluid film.
Unlike liquid immersion “o” according to EN 60079-6, the liquid immersion for non-electrical equipment can also involve electrically conductive fluids.
- **Applications:**
Immersion pumps, oil-filled driving gears, fluid couplings

9.16. Types of ignition protection - Mining

In the area of Group I - Mining, only selected ignition protection types may be applied. Due to the ongoing revisions of the standard series 60079 and 80079, and due to the increasing use of the EPL in the standards, the classification has now become easier.

EPL	Ignition protection type	Code	Standards
Ma	Intrinsic safety	ia	EN 60079-11
	Encapsulation	ma	EN 60079-18
	Optical radiation	op is	EN 60079-28
	Two independent ignition protection types that both fulfil EPL Mb	-	EN 80079-36
Mb	Flameproof enclosure	d	EN 60079-1
	Pressurised enclosure	px	EN 60079-2
	Powder filling	q	EN 60079-5
	Increased safety	eb	EN 60079-7
	Intrinsic safety	ib	EN 60079-11
	Encapsulation	mb	EN 60079-18
	Optical radiation	op is, op sh, op pr	EN 60079-28
	Constructional safety	c	EN 80079-37
	Liquid immersion	k	
	Control of ignition source	b	



Table: Mining ignition protection types – protection provided

10. Marking

10.1. ATEX Directive 2014/34/EU

Products covered by the ATEX Directive are given a CE marking. They are also given a special explosion-protection marking and marked with their equipment group and category.

Example:

  II 2 G	
Equipment group II	(See point 7.1)
Equipment category 2	(See point 7.2)
Type of ex. atmosphere G	(See point 7.3)


If a notified body is involved in the conformity process, this body's ID number is given next to the CE marking. The marking is the same as that of the previous Directive 94/9/EC.

Explosion Protection Directives and Basic Principles


10.2. Marking according to standards requirements

The directive marking is followed by marking in accordance with the standards EN 60079 for electrical devices and EN 80079-36 for non-electrical devices. This involves additional markings indicating the protection classes and area of application.


Example of electrical equipment for areas at risk of gas explosion:

CE  II 1 G	Ex ia IIC T6 Ga
Symbol Ex	
Ignition protection type i protection level a	(See point 9.6)
Group II (gas) C	(See point 4.7)
Temperature class T6	(See point 5.1)
Equipment protection level (EPL) Ga	(See point 8)

Example of electrical equipment for areas at risk of dust explosion:

CE  II 2 D	Ex tb IIIC T80 °C Db
Symbol Ex	
Ignition protection type t protection level b	(See point 9.10)
Group III (dust) C	(See point 4.7)
Temperature class T80 °C	(See point 5.2)
Equipment protection level (EPL) Db	(See point 8)

Example of non-electrical equipment for areas at risk of gas explosion:

CE  II 2 G	Ex h IIC T6 Gb
Symbol Ex	
Ignition protection type h	(see point 9.13-9.15)
Group II (gas) C	(See point 4.7)
Temperature class T6	(See point 5.1)
Equipment protection level (EPL) Gb	(See point 8)

10.3. Markings for special conditions

If a piece of equipment is to be used in special conditions or conditions that differ from the standards, this is indicated with an additional marking.

The letter **X**, for example, indicates differing ambient temperatures or special installation conditions. The special conditions should be indicated on the device wherever possible, and always indicated in the operating manual.

Components that are used in conjunction with other components or devices rather than on their own are marked with **U**. These incomplete components must be included in the certification of the corresponding device.

ATEX marking

Electrical equipment

CE 0158

1	2	3	4	5	6	7	8	9
	II	2	D	EX	ta	IIIC	T80 °C	Db

Marking in acc. with ATEX Directive 2014/34/EU

Marking in acc. with EN standards

5	6	7	8	9	10
EX	h	IIC	T6	Gb	X

Non-electrical equipment

CE

1	2	3	4	5	6	7	8	9	10
	II	2	G	EX	h	IIC	T6	Gb	X

Marking in acc. with ATEX Directive 2014/34/EU

Marking in acc. with EN standards

5	6	7	8	9	10
EX	h	IIC	T6	Gb	X

1. Official inspection authorities (selection) only required if equipment was certified by a notified body	
Notified bodies	ID number
TUV Rheinland	0035
TUV Nord Cert	0044
INERIS	0080
LOIE	0081
PTB	0102
TUV Sud	0123
DEKRA EXAM	0158
DEKRA B.V.	0344
SP	0402
SIRA	0518
VTT	0537
BAM	0589
CESI	0722
SGS BASEEFA	1180
SGS-TUV Saar	1637

2. Equipment groups	
Equipment group I:	Equipment intended for use in underground parts of mines, and in those parts of surface installations of such mines, liable to be endangered by firedamp and/or combustible dust
Equipment group II:	Equipment intended for use in other areas that could be at risk of an explosive atmosphere

3. Equipment categories	
Equipment category M1:	Mining – very high level of safety
Equipment category M2:	Mining – high level of safety
Equipment category 1:	Very high level of safety
Equipment category 2:	High level of safety
Equipment category 3:	Normal level of safety

4. Types of explosive atmosphere	
G (gas):	Mixture of gases, vapours or mists and air
D (dust):	Dust-air mixture

7. Groups	
Gas groups	Typical gases
II A	Propane
II B	Ethylene
II C	Hydrogen
Dust groups	Definition
III A	Flammable substances
III B	Non-conductive dust
III C	Conductive dust

5. EX symbol	
EX	Symbol

6. Types of ignition protection		
Ignition protection types, electric	Symbol	Standard
Flameproof enclosure	d	EN 60079-1
Pressurised enclosure	p	EN 60079-2
Powder filling	q	EN 60079-5
Liquid immersion	o	EN 60079-6
Increased safety	e	EN 60079-7
Intrinsic safety	i	EN 60079-11
Electrical equipment ignition protection type "n"	n_	EN 60079-15
Encapsulation	m	EN 60079-18
Devices with optical radiation	op	EN 60079-28
Protection by enclosure	t	EN 60079-31
Ignition protection types, non-electric	Symbol	Standard
Flow restricting enclosure	fr	EN 13463-2
Flameproof enclosure	d	EN 13463-3
Constructional safety "c"	h	EN 80079-37
Control of ignition source "b"	h	EN 80079-37
Liquid immersion "k"	h	EN 80079-37

8. Temperature classes	
Temperature class, gas	Max. surface temperature in °C
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

In dust ex. area the max. surface temperature is stated directly

9. Equipment protection level (EPL)	
EPL	Category/type of atmosphere
Ma	M1
Mb	M2
Ga	1 G
Gb	2 G
Gc	3 G
Da	1 D
Db	2 D
Dc	3 D

10. Restrictions for equipment	
X:	Indicates special conditions
U:	Ex component with sub-certification, not to be used on its own

Explosion Protection

Directives and Basic Principles

11. Explosion protection worldwide and the legal situation

Over the years, almost every single country has issued its own set of rules for explosion protection. In the context of globalisation, however, national specifications and idiosyncrasies tend to function as a trade barrier. To counter this, initiatives were set up some time ago to harmonise the guidelines for explosion protection. Within in the European Union, this has already been achieved by the ATEX Directives. There is a similar directive for the Eurasian Customs Union. At an international level, the IECEx scheme has been set up by the **IEC (International Electrotechnical Commission)**. Countries, such as the US and Canada, Brazil or Korea, have their own directives. There are already signs however, that approvals issued on the basis of the IECEx scheme could be expanded faster to national certificates in these countries.

11.1. Europe – ATEX Directives

The EU has issued two harmonised directives for Europe relating to health and safety.

- **Requirements for machinery and equipment**

Directive **2014/34/EU** of the European Parliament on the harmonisation of the laws of the Member States concerning equipment and protective systems for use in potentially explosive atmospheres. This directive governs the use of both electrical equipment and non-electrical equipment in potentially explosive areas. It is mainly targeted towards the manufacturers of equipment and components that are to be used in potentially explosive areas. It replaced the first ATEX directive 94/9/EC. As of 20 April 2016, all new products launched on the market must be certified in accordance with the new Directive 2014/34/EU. All certificates issued under Directive 94/9/EC will remain valid, however.

The ATEX directive refers to article 114 of the EU Treaty on free movement of goods (Lisbon Treaty). This is why the directive is sometimes also called ATEX 114. In older documents, the name ATEX 95 is used (article 95 of the EC Maastricht Treaty).

- **Requirements for the system builder/owner**

Directive **99/92/EC** (ATEX 153) defines the minimum requirements for health and safety in workplaces, for operating conditions and for the handling of products and materials in potentially explosive atmospheres. The directive divides up the workplace into zones and defines criteria for categorising the products inside these zones.

- **Transposition into national law**

The directives have been transposed into national law in the countries of the European Union.

11.2. International rules – IECEx

The IEC publishes globally standardised regulations for electrical technology and electronics. Technical committees compile the standards for the various specialist areas. To ensure harmonisation, the standards published by the IEC are mainly adopted in national and European standards without any major changes made. IEC publications concerning the explosion protection of electrical devices and systems are compiled by the Technical Committee TC31. As a certification scheme, the **IECEx** creates a global framework for the independent inspection and certification of devices and services relating to explosion protection.

Like ATEX, IECEx divides the areas at risk into zones on the basis of the frequency and duration of the hazard.

11.3. USA – NEC

In the US, electrical equipment that is used in potentially explosive areas is governed by the **National Electrical Code (NEC)**.

Unlike the regulations in Europe and the IECEx scheme, the NEC 500–504 divides the potentially explosive areas into three classes (Classes I to III for gases, dusts and fibres) and two divisions for the frequency and duration of the presence of these substances. In 1996, NEC 505–506 introduced a zone model similar to the international scheme, parallel to the class model.

Equipment that is to be used in mining is certified according to the regulations of the **Mine Safety and Health Administration (MSHA)**.

11.4. Canada – CEC

In Canada, approval is issued in accordance with the **Canadian Electrical Code (CEC 18)**. The classification of the areas was previously based on the division model, as is the case in the US. Since the last revision of the CEC from 2015, for new systems and new designs, the zone model exclusively applies, similar to the IECEx. Old equipment according to the division model may be continued to be operated according to the previous regulations (Annex J18). The Canadian provinces decide on the implementation of the CEC separately, in parts, some supplements are added.

11.5. Brazil – INMETRO

Brazil's current set of regulations is the **Inmetro Directive 179/2010**. This directive accepts certificates in compliance with the IECEx scheme directly, but unlike IECEx certificates they are only valid for three years. Other certificates such as ATEX are only recognised if they are harmonised with the IEC standards 60079.

11.6. Eurasian Customs Union – TR CU

Russia formed the Eurasian Customs Union EAC with Belarus, Kazakhstan, Armenia and Kyrgyzstan. This resulted in uniform regulations being implemented in these countries. Explosion protection is regulated in the directive **TR-CU 012/2011**. EAC certificates can be issued for a one-off delivery, for 1, 3 or up to 5 years validity. ATEX or IECEx certificates are accepted as the basis for the EAC certification.

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11.7. India – PESO

In India, electrical equipment in potentially explosive areas needs to be approved by the **PESO – Petroleum and Explosive Safety Organization**. In the approval of equipment the Indian regulations differentiate between devices manufactured in India and devices imported to India. For Indian devices, the national standards apply exclusively, which are based in parts on outdated versions of the IEC or EN standards. For imported devices, IECEx or ATEX certificates according to the latest standards are required. Approval can only be granted by the **CCoE – Chief Controller of Explosives** via an accredited Indian test laboratory. Test reports issued by non-Indian test labs are taken into account in the obligatory inspection.

The **Director General of Mining Safety (DGMS)** is responsible for products used in mining.

11.8. China – NEPSI

Certification in China is similar to the IECEx scheme. It is based on IEC and EN standards that have been adopted directly or modified. ATEX or IECEx certificates can be used as a basis for the Chinese certification. NEPSI certificates must be renewed after five years.

11.9. Korea – KOSHA

Certification is also carried out in accordance with the IECEx scheme in Korea. The Korean regulations are also based on IEC and EN standards that have been adopted without change or modified. ATEX or IECEx certificates that have already been issued can form the basis of certification, although additional national provisions must be taken into account.

11.10. Japan – TIIS

In Japan, electrical equipment used in explosion protection applications must be certified by the **TIIS – Technical Institution of Industrial Safety**. The standards for ignition protection types are mainly based on the standards series IEC 60079. However, in parts, older versions of these standards were harmonised and changes and deviations were included. TIIS certificates are valid for 3 years and then need to be renewed or extended. The standards only apply for devices for areas at risk of gas or dust. Group I (mining) devices do not fall under the TIIS scheme, and also do not play a great economic role, as there is only one remaining commercial coal mine in Japan.

11.11. Australia, New Zealand

Australia and New Zealand have adopted the IECEx scheme in their national regulations. This means that IECEx-certified products can be used directly. The only exception is the state of Queensland, which still has some independent authorisations. The Secretariat for the IECEx system is based in Australia.

12. Comparison of the main approval regulations ATEX – IECEx – NEC

12.1. ATEX

ATEX is a regulation that aims to facilitate free trade within the EU. It prescribes essential safety precautions to protect workers. The ATEX Directive governs both electrical and non-electrical equipment and includes equipment used in mining.

The manufacturer has to provide verification of safety and conformity with the directive. This verification forms the basis of authorisation to launch equipment for potentially explosive areas on the market. The conformity procedure has different levels depending on the equipment's group/category, with a notified body needing to be involved in some cases.

A notified body is a conformity assessment body (such as TÜV-Süd or DEKRA) accredited by an EU authority that is authorised to perform conformity assessments in accordance with the directives as an independent third party. A list of the notified bodies is available on the European Commission's official website (<http://ec.europa.eu/growth/tools-databases/nando/index.cfm>).

As the CE marking is to be issued in a conformity assessment based on the ATEX Directive it can sometimes be necessary to include other EU directives.

It is not mandatory to apply the harmonised standards. However, if the standards are fulfilled, there is a presumption of conformity – that is, the safety precautions are considered to be fulfilled. Specifications or draft standards can also be used in the assessment. This allows new technical developments to be accommodated immediately.

The certification documents are kept by the notified body or by the manufacturer. They are not available for the user to access.

12.2. IECEx

The **IECEx Equipment Scheme** is an all-inclusive certification procedure. It covers the type test, manufacturer monitoring, product testing during production, inspection of the quality system and market surveillance. Originally developed mainly for electrical equipment, the IECEx Equipment Scheme has since been expanded to cover non-electrical equipment.

The relevant IEC and ISO standards need to be fulfilled. The certificates are issued by an independent third party.

In addition to the IECEx Equipment Scheme for the certification of equipment, there is also a certification system for repair workshops (**IECEx Certified Service Facility Scheme**) and an **IECEx Certification of Personal Competences** to certify the skills of explosion experts. This is intended to ensure that standards remain harmonised in the selection of service providers in equipment and system project planning and in the skills of workers in service and maintenance.

The IECEx system does not cover the workplace layout and assessment like ATEX 153 does. This is still governed by the national public authorities.

All documents and issued certificates can be downloaded from the IECEx website (www.iecex.com).

Although all major industrial states actively participate in the IEC and the IECEx system, only a few countries recognise the IECEx certificates directly. In most cases it is still necessary to involve national bodies.

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12.3. NEC 500–504

In the US, a system has been developed for explosion protection that significantly differs from the IECEx/ATEX systems that are customary worldwide. The US system divides up the potentially explosive areas in a different way and takes a different approach to the design of equipment and the installation of systems.

Unlike IECEx and ATEX, it divides up flammable substances in three different classes:

Class I covers flammable gases, vapours and mists. They are divided into groups A to D on the basis of their flammability, with the most hazardous substances such as acetylene assigned to **Group A** and substances such as propane gas assigned to **Group D**. This division is quite different to the more common way of dividing the gas groups, with Group A containing the least hazardous gases and Group C containing highly hazardous gases such as acetylene.

Dusts are assigned to **Class II**. Like the gases, the dusts are subdivided into groups on the basis of the material type: **Group E** contains metal dusts, **Group F** dusts that contain carbon and **Group G** organic dusts such as grain dust.

There is also a **Class III** that contains flammable organic fibres and lints such as cotton and viscose. This class is not subdivided into groups.

Like the zone system, areas are divided up in NEC 500 according to the frequency and duration of hazardous concentrations. Instead of three zones, there are only two divisions:

Division 1 covers all areas where hazardous concentrations can occur continuously or occasionally under normal conditions – i.e. in normal operation and in regular maintenance and repair work.

Division 2 covers all areas where explosive concentrations can be expected in the event of an accident or malfunction, but are not likely in normal conditions.

The divisions for fibres and lints in **Class III** are slightly different from those for gases and dusts.

Division 1 covers all areas where the materials are worked with or transported between one processing step and the next, while **Division 2** covers all areas where highly flammable fibres and lints are stored or transported separately from processing.

The maximum surface temperatures are categorised in the same way as in the ATEX/IECEx system, in **temperature classes** ranging from **T1** to **T6**. Temperature classes T2, T3 and T4 have additional subclasses. Dusts are divided up in the same temperature classes as gases. Unlike ATEX, NEC 500 does not specify the permissible temperatures directly.

Example of the categorisation of electrical equipment for areas at risk of gas explosion in the division model:

Class I	Division 1	Group A	T4
Hazard class Class I			
Area classification Division 1			
Gas group A			
Temperature class T4			

12.4. NEC 505–506

NEC 505 and 506 are more strongly aligned to the existing international IECEx/ATEX systems than NEC 500 et seq. The areas are divided up into three zones, as in IECEx/ATEX, rather than in divisions. The groups and ignition protection types are also divided up in a similar way to IECEx/ATEX. The temperature classes range from T1 to T6, as they are in IECEx/ATEX, with no additional subclasses.

Example of the categorisation of electrical equipment for areas at risk of gas explosion in the zone model:

Class I	Zone 1	AEx ia IIC T4
Hazard class Class I		
Area classification Zone 1		
Electrical equipment American Standard AEx		
Ignition protection type i protection level a		
Group II C		
Temperature class T4		

Explosion Protection

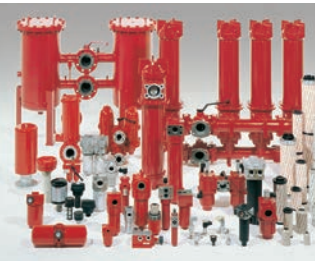
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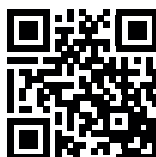
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Note

The information in this brochure relates to the operating conditions and applications described.

For applications or operating conditions not described, please contact the relevant technical department.

Subject to technical modifications.