BARTEC

Basic concepts for explosion protection

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BARTEC brochure
Basic concepts for explosion protection
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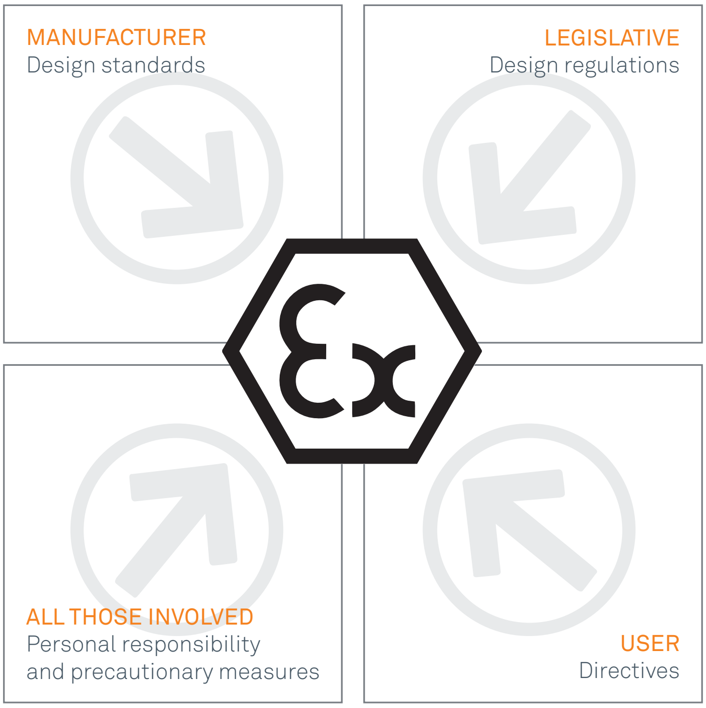
Technical development of explosion protection

Unwanted ignitions are older than mankind. Atmospheric discharges – lightning – triggered fires long before humans walked the earth. In 1753 the first lightning conductor was invented, enabling electrostatic discharges as the sources of ignition for fires to be significantly reduced. Lamps in mining also constituted another high fire risk for many years, because mine air mixed with methane – so-called firedamp – was able to cause explosions when sufficiently strong ignition sources were present. In 1815 Sir Humphry Davy introduced the first mine safety lamp, a non-electrical item of equipment for mining. Two wire glass screens arranged on top of each other separated the flame - which was to be kept as small as possible inside the screen - from the flammable mixture present, while allowing combustion inside the screen. When used correctly, the screens prevented an external ignition.



In the 19th century, electrical equipment was introduced into industry and households. Immediately afterwards, the occurrence of methane and coal dust in hard coal mining prompted the development of the basics of electrical explosion protection. The advantages of electricity were so convincing that intensive work was carried out to find a way to reliably prevent contact between an explosive atmosphere and ignition sources - originating from the use of electrical equipment - and thus prevent explosions.

After bitter experiences in the beginning, the occurrence of firedamp explosions was greatly reduced and well-monitored electrical equipment was utilised with very high safety standards.

Today, fortunately, the number of accidents caused by electrical ignition sources is low. The expenditure on development and manufacturing and the statutory regulations have proven to be successful and the frequently posed question as to “whether such expenditures are justified“ must be answered with yes. Any neglection is comparable to culpable carelessness. Unfortunately there are still numerous examples of explosions that demonstrate the devastating effects on humans, environment and plants.

Priority is given to what is regarded as primary explosion protection, for example the focussing of attention on the use of non-flammable substances that are not capable of forming an explosive atmosphere.

However, it is not always possible to exclude flammable substances such as methane or coal dust in mines, or petrol and in future perhaps hydrogen in vehicles. In such cases protection and safety are provided by equipment which is reliably explosion proof. Such solution, by providing type(s) of protection is referred to as secondary explosion protection.

These days, the construction of explosion proof equipment goes far beyond the field of electrical engineering. As will be demonstrated in the further descriptions, non-electrical equipment will also require testing or at least assessment. Here the knowledge gained by manufacturers over the decades on the explosion proof electrical equipment is particularly important and it now also benefits the manufacturers of non-electrical equipment.

There are many applications which require explosion proof equipment. During the over 100 years of electrical explosion protection, principles and techniques have been developed which allow the use of electrical measuring technology, even where, for example in reaction vessels, an explosive atmosphere is permanently present.

The applications in the mining area were the beginning. The utilisation and processing of mineral oil and natural gas offer a wide scope for using explosion proof equipment. Organic chemistry, the paint industry and the pharmaceutical industry all process flammable liquids and gases. Because of the production and utilisation of biogas and the ecological utilisation of waste dumps, new applications are constantly developing. The utilisation of hydrogen is being discussed in depth, practised in experimental installations and will be in our lives as renewable energy.

Harmonization of explosion protection

Internationally, the standpoints on the explosion protection of electrical and non-electrical equipment are co-ordinated by specialized IEC and ISO working groups. In the area of electrical engineering, internationally harmonized design agreements were formulated in IEC standards at a very early stage. For the most part, this was done in conformance with the CENELEC standards. A visible sign of the harmonisation is that the relevant IEC/ISO (global), EN (Europe) documents on standards agree in content and in the registration number (60079 series). Harmonization is being worked on intensively at present. This reorganization involves continuous amendments but will also make future international work easier. ISO/IEC working groups work in an identical way and use (80079 series) for application to non-electrical equipment.

Under the IECEx System, Ex equipment is developed, tested and certified with a Certificate of Conformity (IECEx CoC) in accordance with the internationally uniform requirements (IEC/ISO standards) and is in the meantime applicable to Ex equipment assemblies consisting of electrical and non-electrical equipment too.

However, certificates are still accepted on the basis of regional (for example in Europe with the manufacturer's EU Declarations of Conformity) and local (for example Brazilian INMETRO certificates, USA UL/FM certificates etc.) statutory and insurance law regulations. It is often necessary to introduce amendments, for example new certification, to conform to national requirements. In international projects, it is therefore important to engage with the users to clarify the details of the specifications with respect to the explosion protection requirements.

With ATEX Directive 2014/34/EU, the European Community has provided itself with binding uniform agreed requirements relating to the explosion protection of systems, equipment and components and these are supported by harmonized EN standards from the CENELEC and CEN standardization committees.

With the help of these standards, the manufacturer is able to assume during the design and assessment of the explosion protection that he is developing safe, protective systems, equipment and components in compliance with ATEX Directive 2014/34/EU, which will then be tested in conformance to uniform and binding inspection processes by an EU-authorized Notified Body. If the test criteria have been met successfully, the Notified Body issues the EU-Type Examination Certificates which ensure fulfilment in Europe of the uniform criteria with respect to the required Essential Health & Safety Requirements (EHSR's) for Equipment with a very high or high safety level. These EU-Type Examination Certificates are a prerequisite for the production and the placing on the market of protective systems, equipment and components with very high and high safety levels, indicated by Category 1 and 2.

For Category 3, with just an enhanced safety level, a different approach is acceptable. The manufacturer may declare on his own responsibility that the Ex Equipment or Ex Component complies, without involvement of a Notified Body. In the meantime more manufacturers are asking the Notified Bodies (on a voluntary basis) to examine the intended proto types and issue Type Examination Certificates.

A uniform classification of hazardous areas (installations) provides a basis for selecting and assigning protective systems and Ex Equipment including their installation. Under EU Directive 1999/92/EC, an Explosion Protection Document is a precondition for setting up and operating a potentially explosive facility. Only such a document makes it possible to select protective systems and equipment with respect to explosion protection and to install, operate, maintain and eventually repair them in compliance with standards. The corresponding technical rules and regulations are drawn up and adopted on a national level.

Directive 2014/34/EU accordingly formulates EU-wide uniform construction requirements for equipment used in hazardous areas while Directive 1999/92/EC contains the minimum requirements for Occupational Health and Safety, which can be increased nationally. Using the two above directives creates a closed system which makes it possible to prevent explosions reliably in order to protect people, the environment and property effectively.

Explosion protection

Explosion

Explosions are suddenly, with huge speed, occurring oxide reactions which generate a temperature and pressure increasement. Most well-known are reactions of flammable gases, vapours or dusts together with oxygen out of the air.

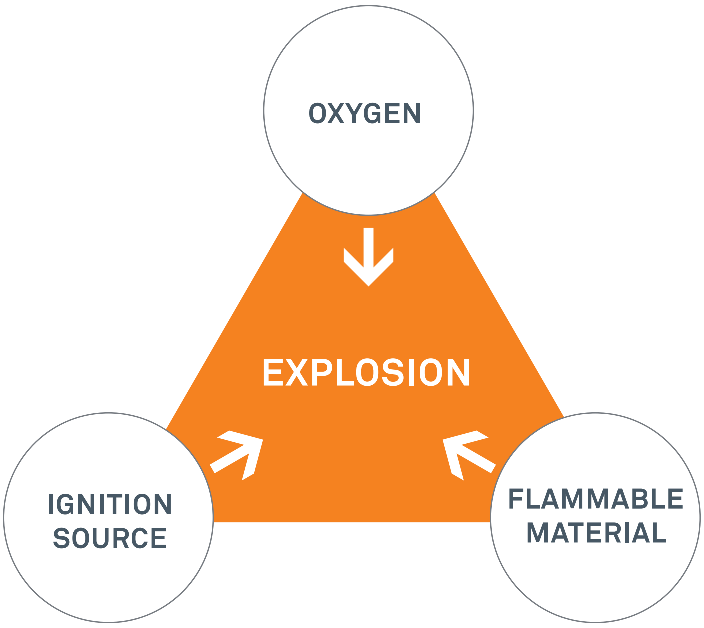
Basis for an explosion

As a rule, for explosions to happen in atmospheric air, three factors have to be present at the same time (see Figure 2):

- **flammable material**
- **oxygen (air)**
- **source of ignition**

In production and work places, hazardous areas can develop wherever the first two preconditions for an explosion are fulfilled. Typical hazardous areas form in chemical factories, refineries, enamelling plants, paint workshops, cleaning equipment, mills and stores for milled products and other combustible dusts, in tank facilities and loading areas for flammable gases, liquids and solids.

The first two preconditions - the flammable material and air - must be present in justified quantities between LFL and UFL (Lower Flammable Limit and Upper Flammable Limit) to form an explosive atmosphere. The statutory definitions of explosion protection - derived from the health and safety at work regulations - are in relation to workplaces. For this reason, explosion protection is generally limited to description of reactions with oxygen in the air. Oxidation reactions normally involve increasements in heat and pressure and therefore fulfil the criteria of an explosion.



Three factors

Flammable material

Flammable material can be either gaseous, a vapour from liquid or solid. For a general discussion relevant to work places, their reactivity with atmospheric oxygen is considered.

Flammable gases

A flammable gas may be an element such as hydrogen which can be made to react with oxygen with very little additional energy. Flammable gases are often compounds of carbon and hydrogen. These flammable gases and vapours require only small amounts of energy to react with atmospheric oxygen.

A vapour is the proportion of a liquid - if talking about the explosion protection of flammable liquids - which has evaporated into the surrounding air as the result of the vapour pressure above the surface of the liquid, around a jet of that liquid or around droplets of the liquid. Mist is a special type, which because of its explosion behaviour, can be included with the vapours, for the purposes of fulfilment of safety considerations.

Flammable liquids (actually the vapour only)

Flammable liquids are often hydrocarbon compounds such as ether, acetone or petroleum spirit. Even at room temperature, sufficient quantities of these can change into the vapour phase so that an explosive atmosphere forms near their surface. Other liquids form such an atmosphere near their surface only at increased temperatures. Under atmospheric conditions this process is strongly influenced by the temperature of the liquid.
For this reason the flash point, or rather the flash point temperature, is an important factor when dealing with flammable liquids. The flash point relates to the lowest temperature at which a flammable liquid will, under certain test conditions, form a sufficient quantity of vapour on its surface to enable an effective ignition source to ignite the vapour air mixture.

The flash point is important for the classification of potentially explosive atmospheres. Flammable liquids with a high flash point are less dangerous than those with a flash point at room temperature or below.

When spraying a flammable liquid, a mist can form consisting of very small droplets with a very large overall surface area, as is well-known from spray cans or from car paint spraying stations. Such a mist can explode. In this case the flash point is of lesser importance. For a fine mist - made from a flammable liquid - the behaviour relevant to safety can be roughly derived from the known behaviour of the vapour.

Flammable solids (actually dust only)

Flammable solids in the form of dust or flyings can react with atmospheric oxygen and produce disastrous explosions. Normally more energy is required for activating the explosion in air than with gases and vapours. However, once combustion starts, the energy released by the reaction produces high temperatures and pressures. In addition to the chemical properties of the solid itself, the fineness of the particles and the overall surface area, which increases with increasing fineness, play an important role.
The properties be determined by processes which take place immediately at the surface of the solid particles. Igniting and extinguishing a paraffin wax candle provides a demonstration of a series of processes undergone by a solid material within a short period of time which cannot easily be presented in a simplified form.

An experiment shows that when the wick of a candle is lit, the paraffin wax melts and then vaporises and that this vapour feeds the flame. After extinguishing the candle, the paraffin vapour can still be smelled, the melted paraffin wax solidifies and the paraffin vapours disperse. Now the paraffin wax candle is once again a harmless object.

Dust reacts very differently, depending on whether it is in a deposited layer or whether it is in a swirled dust cloud. Dust layers are liable to begin smouldering on hot surfaces, while a dust cloud which has been ignited locally or through contact with a hot surface can explode immediately. Dust explosions are often the consequence of smouldering dust layers which become swirled up and already carry the ignition initiation. When such a layer is stirred up, for example by mechanical cleaning methods during transportation or inappropriate extinguishing attempts, this can lead to a dust explosion.

A gas or vapour/air explosion can also swirl up the dust, which then often turns from the first, the gas explosion, into the second, the dust explosion. In deep coal mines methane/firedamp explosions often have triggered off coal dust explosions whose consequences were more serious than those of the original firedamp explosion.

Oxygen

The quantity of oxygen available in the air can only oxidise/burn a certain quantity of the flammable material. The ratio can be determined theoretically, it is called the stoichiometric mixture. When the quantity of the flammable material and the available atmospheric oxygen are near to the optimum (most ideal) ratio, the effect of the explosion - temperature and pressure increase - is most violent. If the quantity of flammable material is too small, combustion will only spread with difficulty or will cease alltogether. The situation is similar when the quantity of flammable material is too great for the amount of oxygen available in the air.

All flammable materials have their explosive range, which also depend on the available activation energy. This is usually determined by igniting the mixture with an electric spark. The explosive range is bounded by the lower flammable (previous referred to as explosive) limit and the upper flammable (previous referred to as explosive) limit. This means that below and above these limits, explosions will not happen. This fact can be utilised by sufficiently diluting the flammable substances with air or by preventing the ingress of air/oxygen into parts of the equipment. The latter option is, however, not or only with restrictions possible in environments where people regularly work (inerting means danger for suffocation) and must therefore be reserved for technological equipment only.

Sources of ignition

With the use of technical equipment a large number of ignition sources are possible. In the following overview the numbers given behind the ignition sources refer to the appropriate clauses of the basic standard: EN 1127-1: 2019 “Explosive atmospheres - Explosion prevention and protection- Part 1: Basic concepts and methodology.”

Hot surfaces (5.1)

arise as a result of energy losses from systems, equipment and components during normal operation. In the case of heaters they are desired. These temperatures can usually be controlled.
In the event of a malfunction - for example with overloading or seized bearings - the energy loss, and therefore the temperature, increases unavoidably. Technical equipment must always be assessed as to whether it is stabilizing - for example whether it can attain a final temperature, or whether non-permissible temperature increases are possible which need to be prevented by taking appropriate measures.
Examples: coils, resistors or lamps, hot equipment surfaces, brakes or overheating bearings

Flames and hot gases (including hot particles) (5.2)

can occur inside combustion engines or analyser equipment during normal operation and when a malfunction has occurred. Protective measures are in such case required which are able to permanently prevent them from leaving the enclosure.
Examples: exhausts from internal combustion engines or particles which are formed by the switching sparks of power switches eroding material from the switch contacts

Mechanically generated sparks (5.3)

are produced for example by grinding and cutting devices during normal operation and are therefore not permitted in a potentially explosive atmosphere. Cracks in rotating parts, or parts sliding over each other without sufficient lubrication or similar situations can generate such sparks when malfunctioning.
Specific requirements to the materials used to produce enclosures serve to reduce the risks from such ignition sources.
Examples: tools such as a rusty hammer and chisel in contact with light alloys or the metal fork of a fork lift truck

Electrical equipment and components (5.4)

must normally be regarded as a sufficient ignition source. Only very low energy sparks with energies of only a few micro Joules (= micro Watt seconds) may be regarded as too weak to start an explosion. For this reason, suitable measures must be adopted to prevent these ignition sources.
Examples:switching sparks, sparks at collectors or slip rings

Stray electric currents, cathodic corrosion protection (5.5)

which then may result in a potential difference between different earthing points. This is why a highly conductive connection to all the electrically conductive parts of the equipment must be provided so that the potential difference is reduced to a safe level. It is not relevant whether the conductive equipment is electrical or non-electrical parts of the installation, as the cause of the current may be found outside of the equipment.
An equipotential bonding shall always be provided, irrespective of whether or not such currents are expected or whether its sources are known.
Examples: Electric railways and other earthed voltage supplies for example for electric corrosion protection of equipment

Static electricity (5.6)
Independently of whether or not there is an electrical voltage supply, electrical sparks can be caused by static discharges. The stored energy can be released in the form of sparks and function as an ignition source. Because this ignition source can arise quite independently of an electrical voltage supply, it must also be considered with non-electrical devices and components. It is connected with separation processes; therefore these cases must be assessed where this ignition source needs to be taken into account.

Friction during normal operation can be the cause of electrostatic charging. For example, portable devices cannot - due to their portability - either be earthed or connected to potential equalization. When interacting with the clothes of the user, static charging can occur during normal operation. Static electricity must be prevented from becoming an ignition source by taking appropriate measures.
Examples: Transmission belts made from plastic materials, enclosures of portable devices, synthetic clothing material. Separation processes when rolling out paper or plastic film, plastic transport tubing systems

Lightning (5.7)
and the impact of lightning can result in the ignition of an explosive atmosphere. Lightning always results in the ignition of an explosive atmosphere, so there is a need for lightning distraction. However, there is also a possibility of ignition due to the high temperature reached by lightning distraction routes.
Large currents flowing from where the lightning strikes can produce sparks in the vicinity of the point of impact.

Radio frequency (RF)
electromagnetic waves from 104 kHz to 300 GHz are not the only ignition sources where radiation energy enters the explosive mixture, the following needs to be listed:

Electro-magnetic radiation - radio RF waves (5.8),

Electro-magnetic radiation - IR, visible and UV light (5.9),

Ionising radiation - röntgen and gamma (5.10),

Ultrasonic (5.11).
Systems, devices and components that use radiation may be set up and operated in the Ex area if their parameters are limited permanently and reliably and this equipment is checked.
Examples: transmitting and receiving equipment, mobile telephones, photoelectric barriers and scanners

Adiabatic compression and shock waves (5.12)
inside tube-shaped structures operated at negative pressure can also become a source of ignition.
Examples: transport tubes with narrow passage, breakage of a long fluorescent tube in a hydrogen/air atmosphere

Exothermic reactions (5.13)
are together with self-ignition of dusts the finally defined possible type of ignition sources.

Explosion Range (limits)

In the internal combustion engine the three factors work together effectively: petrol, air/oxygen and the ignition spark produce an explosion inside the enclosed cylinder. For this to take place, the ratio of petrol to air must be correct. If the petrol tank is empty, the air filter blocked or if the ignition does not work, one of the components for triggering this explosion is missing and the motor will not start. Combustible materials mixed with air have a lower and an upper flammable limit and the explosive range lies between these limits. When considering the safety of the workplace, the lower flammable limit is the more important value. In many cases, a possible concentration ≤ 10 % of this value is considered to be safe.

Prevention of explosions

Explosion proof equipment is able to exclude one of the preconditions for an explosion - the ignition source - and is in that way an important contribution to explosion protection. In domestic areas, architectural measures ensure that normally an explosive atmosphere cannot be formed. The conscious restriction of these measures, for example the intended, unimpeded flow of flammable gases or a reduction in ventilation can lead to explosions if an ignition source is also present.

The easiest and most simple way to understand small and safe explosions is by looking at a gas lighter. When the nozzle of the lighter is opened, it releases a small amount of flammable gas. This gas mixes with the surrounding air, the spark from the flint ignites the mixture, and a weak sound is heard - the burning. Some distance away from the nozzle the proportion of the flammable gas is already so low that the explosion and the flame are restricted to the immediate vicinity of the nozzle. In other words, the design of the gas lighter has ensured that it is safe to use.

The effect of an explosion in enclosed spaces and under non-atmospheric conditions - for example under increased pressure - is often more powerful. Just think of the useful application of explosions in vehicle engines.

To attain effective explosion protection against non-controlled, unintended explosions linked to disastrous consequences, it is necessary to remove one of the three factors.

BARTEC products prevent effective ignition sources from getting in contact with potentially explosive atmospheres. They effectively prevent explosions because the other two factors - the oxygen in the air and often the flammable substance - cannot be reliably and permanently ruled out in workplaces.

Primary explosion protection

Primary explosion protection aims at either substituting or reducing the quantity of the flammable substances or the atmospheric oxygen to a level where there is no danger of an explosive mixture forming.

Increased air supply air flushing through ventilation can be achieved by structural measures; for example the open layout of filling stations where the potentially explosive atmosphere is very small.

Replacing the atmospheric oxygen is not an option for areas where people work. For this reason the measures available for such locations are limited to:

- avoidance or restriction of flammable substances which are capable of forming an explosive atmosphere
- avoidance or restriction of release of the flammable substances and therefore formation of explosive mixtures, both inside and around fittings/valves,

  for example by:

  - limiting their concentration
  - using enclosures filled with an inert substanc
  - natural or artificial ventilation
  - concentration monitoring by means of a gas detection system, which will give an alarm and/or switch off the system

Secondary explosion protection

If, despite primary explosion protection measures, it is possible for a hazardous, potentially explosive atmosphere to form (to a degree that requires measures to protect employees against explosion hazards), the ignition of this hazardous, potentially explosive atmosphere must be effectively prevented. All possible sources of ignition are evaluated, and the appropriate protective measures applied.

Effective sources of ignition on equipment and installations can, for example, be prevented using types of protection corresponding to the necessary level of protection. The classification of potentially explosive areas into zones (The frequency and duration of the occurrence of a hazardous explosive atmosphere and the local environmental conditions) forms the basis for defining the level of protection for equipment. It is furthermore necessary to know the key explosion-related figures for the flammable materials (grouping, temperature classes, dust ignition and smouldering temperatures) as well as the local ambient conditions.

The explosion characteristics help the owner/managing operator to specify the risk in the area precisely and help the operating equipment manufacturer to select a suitable solution for the operating equipment and finally they help the installation engineer to select and assign the suitable Ex Equipment. Ultimately, this data is found in the Ex Equipment labelling.

The procedures for applying secondary explosion protection measures will be described in greater detail in the following chapter.

Tertiary explosion protection

If the primary and secondary explosion protection measures are not enough, additional protective measures shall be taken. The purpose of these is to limit the impact of an explosion and/or to reduce it to an occupational health and environmental safe level. The most common measures to limit the hazardous effects of explosion are as follows:

- Explosion-resistant design: containers, apparatus, pipelines are built to be pressure shock resistant in order to withstand an explosion inside.
- Explosion relief: bursting discs or explosion flaps are deployed which open in a safe direction if an explosion occurs and make sure that the plant is not subjected to strain over and above its explosion resistance.
- Explosion suppression and preventing propagation of the explosion: Explosion suppression systems prevent attainment of the maximum explosion pressure by rapidly injecting extinguishing agents into containers and plant. Explosion decoupling restricts possible explosions to individual parts of the plant.

Secondary explosion protection

Protection principles are defined to exclude equipment and components to become ignition sources.

Relevance and advantage of the area classification in workplaces

The practice has been established of dividing potentially explosive atmospheres into zones. This classification takes the different dangers from explosive atmospheres into account and allows explosion protection measures to be taken which reflect the situation both from the point of view of safety engineering and of economic efficiency. For the European community, the zone definitions are uniformly provided in Directive 1999/92/EC. It must be applied with technical understanding of the specific situation.

Pump house (gases and vapours)

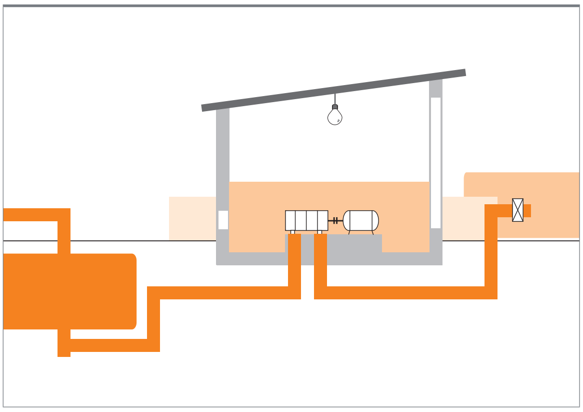


Figure 4

Silo (dust)

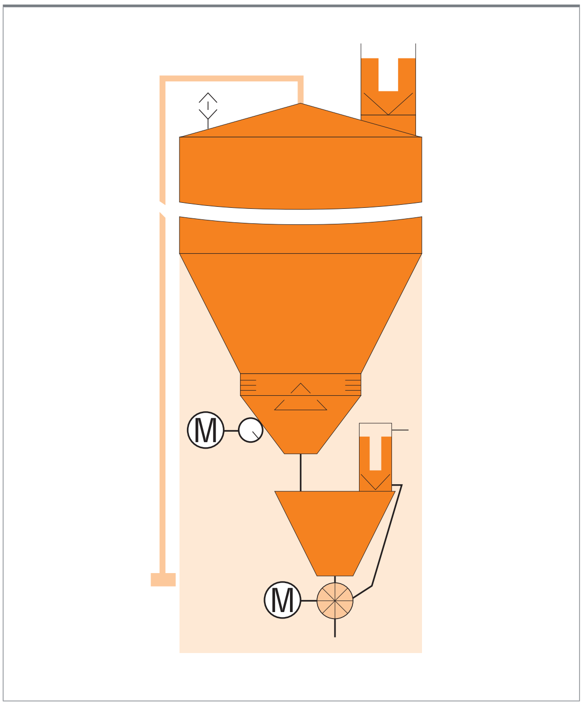


Figure 5 (Source: Firm of AZO, Osterburken)

Caption

■	Zone 0, Zone 20
■	Zone 1, Zone 21
■	Zone 2, Zone 22

Classification of hazardous areas

Gases, vapours

Zone 0
area 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
area in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally
Zone 2
area 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

Dusts

Zone 20
area in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently
Zone 21
area in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur, occasionally, in normal operation
Zone 22
area in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

IEC 60079-10-1 assumes an approximately similar classification for gases and vapours which will also apply to facilities constructed in accordance with the US standard NEC 505. IEC 60079-10-2 provides support for the zone classification with dusts and will also apply to facilities constructed in accordance with the US standard NEC 506.

Potentially explosive atmospheres are classified depending on the frequency and duration of the explosive atmosphere. This classification provides the scope of the measures to be taken according to Annex II section A in the Directive 1999/92/EC in conjunction with equipment categories according to Annex I of the Directive 2014/34/EU.

In workplaces the potentially explosive atmospheres are normally classified at most as Zone 1 or 2 and 21 or 22. Zone 0 and 20 are restricted to very small inaccessible areas in work places or are usually restricted to the inside of technical equipment.

Notes:

1. Layers, deposits and heaps of combustible dust shall be considered as any other source which can form an explosive atmosphere.
2. ‘Normal operation’ means the situation when installations are used within their design parameters.
3. The definitions for explosive atmospheres comply with the European directives and EN-IEC standards:
   - Explosive atmosphere:
     this is a mixture of air and flammable substances in the form of gases, vapours, mists or dusts under atmospheric conditions in which, after ignition has occurred, combustion spreads to the entire unburned mixture.
   - Hazardous explosive atmosphere:
     this is an explosive atmosphere that causes damage on explosion, and which necessitates the introduction of measures to protect employees from explosion hazards.

Organizational measures

The requisite preconditions for the safe operation of electrical equipment in potentially explosive atmospheres are created in a joint effort by the manufacturers of explosion protected equipment and the constructors and operators of industrial plants. It is important that the operator of such plants should ensure that their personnel know how the danger of explosions is likely to arise and the measures that are to be taken to prevent it.

The employees should be regularly trained on the contents of the explosion protection document in accordance with the Directive 1999/92/EC (occupational safety regulations) and informed by means of written corporate regulations which should be regularly updated.

Explosion parameters

In order to allow a combination of measures for explosion protection, which is optimized with respect to the chemical-physical properties of the flammable gases, vapours or dusts, to be made, and therefore a standardization of the types of protection to be possible for the manufacturer, a system of explosion parameters has been created. These are determined using an application-orientated test-method.

Before flammable substances can react with the atmospheric oxygen in an explosion, energy must be provided.

This energy may, for example, be exchanged on a surface. A heated surface increases the energy content of the explosive mixture in contact with it. If the surface temperature is sufficiently high, this increased energy content can lead to the explosive reaction. However, the energy may also be supplied through a spark or a hot gas jet flowing out of a gap into the explosive mixture. Both types lead to different explosion parameters being defined.

Ignition temperature

Gases/vapours temperature class

Many factors such as size, shape, type and surface quality have an influence on the ignition temperature. ISO, IEC and CENELEC have agreed on a method for gases and vapours defined in EN-ISO/IEC 80079-20-1 „Method of test for auto ignition temperature (AIT)". This method is defined in such a way, that a value very close to the lowest practically possible, is determined.

By means of this method, gases and vapours are divided into temperature classes. According to these temperature classes, the surface temperatures in explosion protected equipment and other technological objects is designed in such a way that ignition by the surface is not possible. In the standard, permissible excess values and necessary safety margins below these standard values are defined in detail.

Temperature classes	Ignition temperature range of the mixture	Permissible surface temperature of the electrical equipment
T1	> 450 °C	450 °C
T2	> 300 °C ... ≤ 450 °C	300 °C
T3	> 200 °C ... ≤ 300 °C	200 °C
T4	> 135 °C ... ≤ 200 °C	135 °C
T5	> 100 °C ... ≤ 135 °C	100 °C
T6	> 85 °C ... ≤ 100 °C	85 °C

Table 1

Ignition temperature from dusts (layer and cloud)

For different types of dust, the method for determining the ignition temperature has been unified and coded in document EN-ISO/IEC 80079-20-2. Please note that dust in its deposited form (layer) has a different ignition (read: smouldering) temperature than in its stirred form (cloud).

The permissible surface temperature for those parts of systems and equipment is determined by subtracting 75 K ($T_{max.} = T_{5\,mm} - 75$ K) from the smouldering temperature value determined for the 5 mm dust layer and by taking 2/3 ($T_{max.} = 2/3\ T_{Cloud}$) of the ignition temperature value determined for the dust cloud.

The permissible surface temperature of the equipment shall always be smaller than the lowest outcome of the Tmax. values determined by using above mentioned formulas. Temperature classes are not defined for dust, so a concrete type of dust must always be considered. The parameters are made available in comprehensive tables, laboratories determine the values on request, and a small, non-official overview is contained in the following table 2.

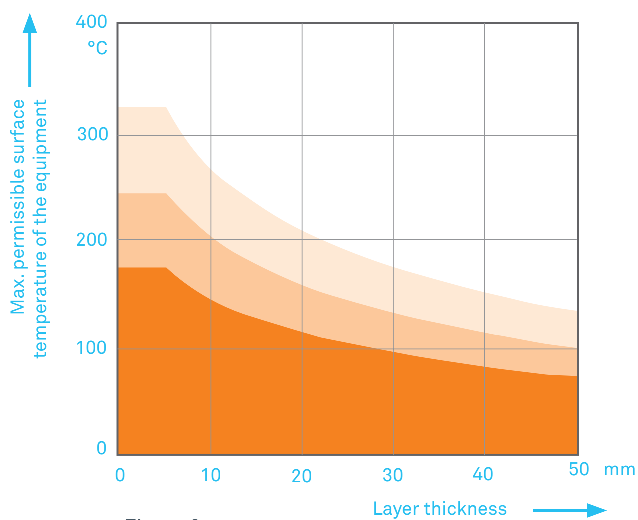


Figure 6

Examples of the ignition temperatures of different types of dust

Designation of the solid material	Ignition temperature EN-ISO/IEC 80079-20-2 $T_{5\text{ mm layer}}$ (°C)	Ignition temperature EN-ISO/IEC 80079-20-2 T_{Cloud} (°C)	Permissible surface temperature of the equipment lowest value of the calculation ($T_{5\text{ mm layer}}$ -75K) and 2/3*T_{Cloud}									
			> 300 ...450	> 280 ...300	> 260 ...280	> 230 ...260	> 215 ...230	> 200 ...215	> 180 ...200	> 165 ...180	> 160 ...165	> 135 ...160
Dust from natural materials (examples)												
Cotton	350	560			275							
Brown coal	225	380										150
Cellulose	370	500		295								
Cereals	290	420						215				
Sawdust (wood)	300	400					225					
Cocoa	460	580	385									
Cork	300	470					225					
Fodder concentrate	295	525					220					
Milk powder	340	440			265							
Paper	300	540					225					
Soya	245	500								170		
Starch	290	440						215				
Hard coal	245	590								170		
Tobacco	300	450					225					
Tea	300	510					225					
Wheat flour	450	480	320									
Dust of chemical technical products (examples)												
Cellulose ether	275	330							200			
Isosorbide dinitrate	240	220										146
Unvulcanised rubber	220	460										145
Petroleum coke	280	690						205				
Polyvinyl acetate	340	500			265							
Polyvinyl chloride	380	530	305									
Soot	385	620	310									
Laminated plastic	330	510				255						
Sulphur	280	280							186			
Metal dusts (examples)												
Aluminium	280	530						205				
Bronze	260	390							185			
Iron	300	310						206				
Magnesium	410	610	335									
Manganese	285	330						210				

Table 2

Equipment sub-groups for Gases/Vapours

Minimum ignition current ratio (MIC), Maximum experimental safe gap (MESG)

Ignition on a hot surface occurs in a relatively large „macroscopic" part of the mixture volume. In contrast, the ignition from a spark spreads in a relatively small „microscopic" part of the mixture volume. The interruption of a predefined resistive/inductive electric circuit can be used for classifying gases and vapours according to their ease of ignition in the microscopic part of the mixture volume (in the µJ range).

For the assessment of the ignition of gases and vapours in a circuit using an intrinsically safe equipment as defined in EN-IEC 60079-11, a comparative value with methane as reference in a standardised circuit is used. This comparative value is the minimum ignition current ratio, MIC. It is the means used for classifying gases and vapours within explosion group II in the subgroups IIA, IIB and IIC, where methane becomes ratio 1.

An analogous grading is done when the ignitability of a hot gas jet escaping from a gap is used for the classification. In EN-ISO/IEC 80079-20-1 „Method of test for the maximum experimental safe gap", a test apparatus is agreed in which a spherical gas volume of 20 cm³ is formed by two hemispheres. These have a 25 mm wide flange. This ball-shaped object is placed into a larger vessel and both spaces are filled with the mixture for which the safe gap is to be determined. The gap between the 25 mm wide flanges for which ten ignitions inside the ball volume just fail to ignite the mixture in the outer vessel is a value specific to the mixture and is called the maximum experimental safe gap, MESG.

The processes involved in the prevention or spread of the explosion in the gap are very complex. Classifying the gases and vapours by the safe gap results approximately - with a small overlap - in the same classification as that obtained with the minimum ignition current ratio. EN-ISO/IEC 80079-20-1 provides an overview of the classification using the two measuring methods MESG and MIC.

The safe gap value is of considerable importance for designs of protection type „Flameproof enclosure"; the value for the minimum ignition current ratio is important for those of protection type „Intrinsic safety". For these two types of protection, the subgroups IIA, IIB and IIC for gases and vapours are relevant. The information on gases and vapours can also be applied approximately to mists.

For the assessment of conditions concerning Intrinsic safety, the MIC ratio values are not commonly used. As there is to deal with Voltages as well, it is preferable to use the M I E minimum Ignition Energy [in Joule] of gases and vapours where a general accepted, but indicative, table is available for Group IIA, IIB or IIC, as follows:

- IIA MIE = 180 µJ
- IIB MIE = 60 µJ
- IIC MIE = 20 µJ

Equipment sub-groups for combustible Dusts

From the point of view of electrical engineering, it is not possible to classify dust as precisely as the chemically defined gases and vapours. For that reason, it is considered sufficient to divide the dust according to type and conductivity. EN-ISO/IEC 80079-20-2 contains the test method to determine the specific electrical resistance of dust. Dust is divided into 3 sub-groups:

- IIIA combustible flyings
- IIIB non-conductive combustible dust, specific electrical resistance $> 10^3\ \Omega \cdot m$
- IIIC conductive combustible dust, specific electrical resistance $\leq 10^3\ \Omega \cdot m$

The minimum ignition energy, a parameter similar to the minimum ignition current, is determined in accordance with EN-ISO/IEC 80079-20-2 for combustible dusts or flyings and is in the mJ range (a factor 1000 higher than the MIE for gases and vapours).

The following table shows examples of the assignment of gases and vapours to the respective temperature classes and explosion sub-groups

Subgroups (Marking)				
IIA	IIB	IIC	Assignment of the gases and vapours acc. to Ignition temperature	Temperature class
Acetone Ammonia Benzene Acetic acid Ethane Ethyl acetate Ethyl chloride Methane Methanol Methylene chloride Naphthalene Phenol Propane Toluene	Carbon monoxide Town gas	Hydrogen	> 450 °C	T1
n amyl acetate n butane Acetic anhydride	Butanol (butyl alcohol) Ethanol (ethyl alcohol) Ethylene Ethylene oxide	Acetylene (Ethine)	> 300 °C to < 450 °C	T2
Cyclohexane Petroleum Diesel fuel Jet fuel (Kerosene) n hexane	Hydrogen sulphide		> 200 °C to < 300 °C	T3
Acetaldehyde	Ethyl ether		> 135 °C to < 200 °C	T4
			> 100 °C to < 135 °C	T5
Ethyl-nitrite		Carbon disulphide	> 85 °C to < 100 °C	T6

Assignment of the gases and vapours acc. to

1. Maximum experimental safe gap (MESG)		
> 0.9 mm	0.5 mm < MESG < 0.9 mm	< 0.5 mm
2. Minimum ignition current ratio (MIC ratio) (related to methane = 1)		
> 0.8	0.45 < MIC < 0.8	< 0.45
Subgroups (Marking)		
IIA	IIB	IIC

Table 3

Protection principles

Protection principles are defined to prevent equipment and components becoming ignition sources.

The protection principles can be applied to electrical and non-electrical equipment and for gases and dusts. The principles allow for a design in various safety categories in accordance with the Directive 2014/34/EU or the Equipment Protection Level (EPL) according to EN- IEC 60079-0 series:

Equipment category 1	very high level of protection and thus a very high degree of safety
Equipment category 2	high level of protection and therefore a high degree of safety
Equipment category 3	normal level of protection and therefore a conventional degree of safety
Equipment Level of Protection a	very high level of protection and thus a very high degree of safety
Equipment Level of Protection b	high level of protection and therefore a high degree of safety
Equipment Level of Protection c	normal level of protection and therefore a conventional degree of safety

Ignition sources which are caused by sparks from friction or impact or from electro-static charging have to be prevented in explosion protected equipment by selecting appropriate materials and by constructive measures, and this must be verified and confirmed by appropriate tests. Four protection principles can prevent equipment from becoming an ignition source. The types of protection listed as examples in the overview are discussed in a different chapter.

An important precondition for all the protection principles is that parts which are in unhindered contact with the explosive atmosphere must not be able to reach non-permitted temperatures with respect to the ignition temperature of substances present in the site of installation. This means that the ignition temperature is relevant for all protection principles.

Explosive mixtures can enter the equipment in which an ignition source may be located and be ignited. The transmission of internal ignition to the surrounding atmosphere shall be excluded.
Examples of types of protection:

- Flameproof enclosures (Ex d) - electrical and non-electrical equipment
- Powder (quartz) filling (Ex q) - electrical equipment

The operating equipment has an enclosure which prevents the penetration of the explosive mixture and/or contact with the internal function-related potential sources of ignition.
Examples of types of protection:

- Pressurized enclosures (Ex p) - electrical and non-electrical equipment
- Protection by enclosures (Ex t) - electrical equipment
- Liquid immersion (Ex o) - electrical equipment
- Liquid immersion (Ex h (previous k)) - non-electrical equipment
- Encapsulation (Ex m) - electrical equipment

Explosive mixtures can penetrate the enclosure of the operating equipment but is not allowed to be ignited. Any spark is prohibited and temperatures capable of causing ignitions shall be prevented.
Examples of types of protection:

- Increased Safe equipment (Ex e) - electrical equipment
- Non-sparking equipment (Ex nA) - electrical equipment
- Protection by constructional safety (Ex h (previous c)) - non-electrical equipment

Explosive mixtures can penetrate the enclosure of the operating equipment but can’t be ignited. The occurrence of spark energy and increased temperatures shall be limited.
Examples of types of protection:

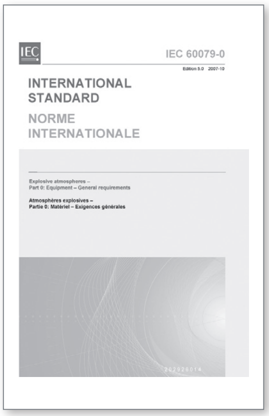
- Intrinsically safe (Ex i) - electrical equipment
- Protection by control of ignition source (Ex h (previous b)) - non-electrical equipment

Design standards and prevention of effective sources of ignition in electrical devices

Hazards arising from the handling of flammable gases, vapours and dusts are caused by uniform chemical and physical processes. For this reason, the protection against these hazards must be carried out in a uniform manner.

Nearly universal uniform requirements have now been formulated by the International Electrotechnical Commission IEC, which are adopted by the European Standardisation Committee CENELEC.

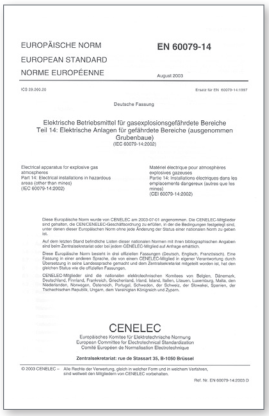
Manufacturers and operators are required to adhere to these, and where there are legal rules, they are monitored by Notified Bodies and the authorities.



IEC 60079-0

INTERNATIONAL STANDARD

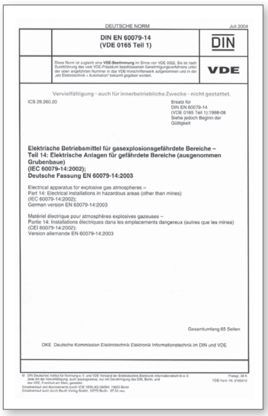
NORME INTERNATIONALE



EUROPÄISCHE NORM
EUROPEAN STANDARD
NORME EUROPÉENNE

EN 60079-14

CENELEC



DIN EN 60079-14 (VDE 0165 Teil 1)

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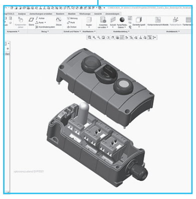
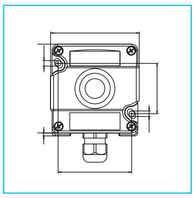
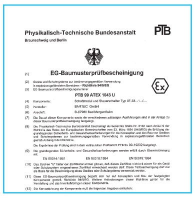


Product idea



Designed in compliance with EN IEC 60079 series design standards (gases, vapours and dust)



Testing and certification by a Notified Body EU-Type Examination Certification or by a Certification Body IECEx Certificate of Conformity

Manufacturer's recognised Quality Assurance Notification in compliance with Directive 2014/34/EU or IECEx System (QAR) both based on EN-ISO/IEC 80079-34

Manfacturing - routine tests

Selection and installation in compliance with the EN-IEC 60079-14

Initial Inspection and Commissioning in compliance with Directive 1999/92/EC

Maintenance and repair in compliance with Directive 1999/92/EC, national requirements EN-IEC 60079-17 EN-IEC 60079-19

Standards for explosion protection

An overview of the standards for the determination of the parameters, the classification of zones, the design criteria for protective systems, equipment and components as well as design, installation and operation in the area where explosive gases, vapours and dusts are present, is shown in the table below which is due to Maintenance Team work subject to subsequent changes.
Stand: August 2020

Title/contents	Registration No.	
	ISO/IEC	CEN/CENELEC
Explosion protection principles and key figures		
Principles		
Explosive atmospheres - Explosion prevention and protection - Part 1: Basic concepts and methodology	-	EN 1127-1
Explosive atmospheres - Explosion prevention and protection - Part 2: Basic concepts and methodology for mining	-	EN 1127-2
Potentially explosive atmospheres - Terms and definitions for equipment and protective systems intended for use in potentially explosive atmospheres	-	EN 13237
International Electrotechnical Vocabulary (IEV) Part 426: Equipment for explosive atmospheres www.electropedia.org	IEC 60500-426	
Explosive atmospheres - Part 32-1: Electrostatic hazards, guidance	IEC TS 60079-32-1	CLC/TR 60079-32-1
Explosive atmospheres - Part 32-2: Electrostatic hazards - Tests	IEC 60079-32-2	EN 60079-32-2
Key figures for flammable gases, vapours and dusts		
Explosive atmospheres - Part 20-1: Material characteristics for gas and vapour classification - Test methods and data	ISO/IEC 80079-20-1	EN-ISO/IEC 80079-20-1
Explosive atmospheres - Part 20-2: Material characteristics - Combustible dusts test methods	ISO/IEC 80079-20-2	EN-ISO/IEC 80079-20-2

Title/contents	Registration No.	
	ISO/IEC	CEN/CENELEC
Explosion protection on equipment/types of protection		
Types of protection of explosion protected electrical and non-electrical equipment – flammable gases, vapours and dusts		
Explosive atmospheres - Part 0: Equipment - General requirements	IEC 60079-0	EN IEC 60079-0
Explosive atmospheres - Part 36: Non-electrical equipment for use in explosive atmospheres - Basic method and requirements	ISO 80079-36	EN-ISO 80079-36
Types of protection of explosion protected electrical equipment – flammable gases, vapours and dusts		
Explosive atmospheres - Part 1: Equipment protection by flameproof enclosure "d"	IEC 60079-1	EN 60079-1
Explosive atmospheres - Part 2: Equipment protection by pressurised enclosure "p"	IEC 60079-2	EN 60079-2
Explosive atmospheres - Part 5: Equipment protection by powder filling "q"	IEC 60079-5	EN 60079-5
Explosive atmospheres - Part 6: Equipment protection by liquid immersion "o"	IEC 60079-6	EN 60079-6
Explosive atmospheres - Part 7: Equipment protection by increased safety "e"	IEC 60079-7	EN 60079-7
Explosive atmospheres - Part 11: Equipment protection by intrinsic safety "i"	IEC 60079-11	EN 60079-11
Explosive atmospheres - Part 13: Equipment protection by pressurised room "p" and artificially ventilated room “v“	IEC 60079-13	EN 60079-13
Explosive atmospheres - Part 15: Equipment protection by type of protection "n"	IEC 60079-15	EN 60079-15
Explosive atmospheres - Part 18: Equipment protection by encapsulation "m"	IEC 60079-18	EN 60079-18
Explosive atmospheres - Part 25: Intrinsically safe systems	IEC 60079-25	EN 60079-25
Explosive atmospheres - Part 26: Equipment with equipment protection level (EPL) Ga	IEC 60079-26	EN 60079-26
Explosive atmospheres - Part 28: Protection of equipment and transmission systems using optical radiation	IEC 60079-28	EN 60079-28
Explosive atmospheres - Part 29-1: Gas detectors - Performance requirements of detectors for flammable gases	IEC 60079-29-1	EN 60079-29-1

Title/contents	Registration No. ISO/IEC	CEN/CENELEC
Explosive atmospheres - Part 29-4: Gas detectors - Performance requirements of open path detectors for flammable gases: General information and test methods	IEC 60079-29-4	EN 60079-29-4
Explosive atmospheres - Part 30-1: Electrical resistance trace heating - General and testing requirements	IEC/IEEE 60079-30-1	EN 60079-30-1
Explosive atmospheres - Part 31: Equipment dust ignition protection by enclosure "t"	IEC 60079-31	EN 60079-31
Explosive atmospheres - Part 33: Equipment protection by special protection "s"	IEC 60079-33	CLC/TR 60079-33
Explosive atmospheres - Part 35-1: Caplights for use in mines susceptible to firedamp - General requirements - Construction and testing in relation to the risk of explosion	IEC 60079-35-1	EN 60079-35-1
Explosive atmospheres - Part 35-2: Caplights for use in mines susceptible to firedamp – Performance and other safety-related matters	IEC 60079-35-2	EN 60079-35-2
Types of protection of explosion protected non-electrical equipment – flammable gases, vapours and dusts		
Non-electrical equipment for use in potentially explosive atmospheres - Part 2: Protection by flow restricting enclosure 'fr'	-	EN 13463-2
Non-electrical equipment for use in potentially explosive atmospheres - Part 3: Protection by flameproof enclosure 'd'	-	EN 13463-3
Explosive atmospheres - Part 37: Non-electrical equipment for use in explosive atmospheres - Non electrical type of protection constructional safety "c", control of ignition source "b", liquid immersion "k"	ISO 80079-37	EN ISO 80079-37
Explosive atmospheres - Part 38: Equipment and components in explosive atmospheres in underground mines	ISO/IEC 80079-38	EN ISO/IEC 80079-38
Technical specifications and developments		
Explosive atmospheres - Part 39: Intrinsically safe systems with electronically controlled spark duration limitation	IEC TS 60079-39	CLC IEC/TS 60079-39
Explosive atmospheres - Part 40: Requirements for process sealing between flammable process fluids and electrical system	IEC TS 60079-40	
Explosive atmospheres - Part 42: Electrical safety devices for the control of potential ignition sources for Ex-Equipment	IEC TS 60079-42	
Explosive atmospheres - Part 43: Equipment in adverse service conditions	IEC TS 60079-43	
Explosive atmospheres - Part 44: Specification for personal competence	IEC TS 60079-44	
Explosive atmospheres - Part 45: Electrical ignition systems for internal combustion engines	IEC TS 60079-45	
Explosive atmospheres - Part 46: Equipment assemblies	IEC TS 60079-46	
Explosive atmospheres - Part 47: Equipment protection by 2-Wire Intrinsically Safe Ethernet concept (2-WISE)	IEC TS 60079-47	

Title/contents	Registration No.	
	ISO/IEC	CEN/CENELEC
Manufacturing & quality management system		
Explosive atmospheres - Part 34: Application of quality systems for Ex product manufacture	ISO/IEC 80079-34	EN-ISO/IEC 80079-34
Explosion protection in installations		
Classification of endangered areas into gases, vapours and dusts		
Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres	IEC 60079-10-1	EN 60079-10-1
Explosive atmospheres - Part 10-2: Classification of areas - Explosive dust atmospheres	IEC 60079-10-2	EN 60079-10-2
Design, selection, installation, inspection, maintenance and repair of electrical installations		
Explosive atmospheres - Part 14: Electrical installations design, selection and erection	IEC 60079-14	EN 60079-14
Explosive atmospheres - Part 17: Electrical installations inspection and maintenance	IEC 60079-17	EN 60079-17
Explosive atmospheres - Part 19: Equipment repair, overhaul and reclamation	IEC 60079-19	EN 60079-19
Explosive atmospheres - Part 29-2: Gas detectors - Selection, installation, use and maintenance of detectors for flammable gases and oxygen	IEC 60079-29-2	EN 60079-29-2
Explosive atmospheres - Part 30-2: Electrical resistance trace heating - Application guide for design, installation and maintenance	IEC/IEEE 60079-30-2	EN 60079-30-2

Table 4

Note about how to use the table

The table is intended as an overview of information about explosion protection standards and technical specificatons. For specific work requiring the use of the standards and to procure the standards, ask the publishers or the standardisation committees for their updated status.

With the help of this table, the contents listed in the title/contents column can be correlated to the regional (read: EU) equivalents. The EU title does not always need to correspond to the international title.

Some types of protection (read: Ex d, Ex p and Ex t) are listed in basis for electrical equipment, but can be applied for non-electrical equipment too (see: EN-ISO 80079-36).

At BARTEC the product standards are consistently applied for electrical equipment. Conformity is - after the completion of the development at BARTEC - checked by Certification Bodies, test laboratories of the IECEx System as well as Notified Bodies of the European Union, and compliance is monitored and realized using a quality assurance system for every piece of Ex Equipment or Ex Component produced. During the routine test, safety-relevant requirements are checked according to the specifications and confirmed by means of a marking.

BARTEC also supports its customers with non-electrical equipment using the knowledge it has accumulated over decades of experience.

Types of protection

For all types of protection, where parts are in unhindered contact with the explosive atmosphere, it is not permitted to reach unacceptably high temperatures.

Taking into account both the maximum ambient temperature and the heating effect (so-called Delta T), the temperature may attain a maximum value which corresponds to the temperature class (for gases and vapours) or the permissible surface temperature (for combustible dusts) in accordance with which the explosive atmosphere has been classified.

General requirements

Principle

All generally applicable requirements for the operating equipment are summarized in the following standards:

- EN IEC 60079-0
  for electrical equipment
- EN ISO 80079-36
  for non-electrical equipment

The ignition protection standards complement these requirements. Where a requirement is in conflict with a general requirement, the specific one from the type of protection takes presedence.

Uniform protection requirements concerning several types of protection such as protection against electrostatic charging, provision of a equipotential bond for metal enclosures, or mechanical strength against impact, are summarized in the general standards as general technical requirements. Individual, more specific standards can demand either more or less stringent requirements. These requirements are based partially on those for electrical equipment. Deviations for non-electrical equipment are contained in an individual basic standard. The levels of protection a to c, which the equipment has to fulfil can also include different general requirements.

The general temperature range for the application of explosion protected electrical equipment is defined as -20 °C to +40 °C. Permissible deviations extending or restricting the temperature range shall be specified on the equipment.

The parameters such as MESG and MIC ratio for the sub groups IIA, IIB and IIC are determined at approximately +20 °C in the laboratory and apply for a temperature range of ± 40 K - that is to say from -20 °C to +60 °C.

These two temperature ranges take the situation at the workplace into account and a certain heating up of the equipment during operation. The explosion pressure, permissible gap and permissible non-igniting currents change outside this temperature range. This has to be considered when using the equipment, and it can require different test conditions.

Historically, the types of protection were developed on the basis of four protection principles with a high level of safety (today's level of protection b or European Category 2).

By classifying the potentially explosive areas into zones, an attempt is made to graduate the types of protection and assign different protection levels. This is done in the standardisation committees. On one hand, the known Ex n (Zone 2) types of protection are assigned to level of protection c. On the other hand, the stringency of the requirements known up to now for level of protection b (Zone 1/21) have to some extent been increased for level of protection a (Zone 0/20).

Types of protection to electrical equipment

Protection principles	Types of protection	Flammable material	Category 1 EPL a	Category 2 EPL b	Category 3 EPL c
			Very high level of protection	High level of protection	Normal level of protection
All	General requirements EN IEC 60079-0	Gas/vapour (G) dust (D)	+	+	+
Protection principle ensures that an ignition source cannot arise.	Increased safety Ex e EN IEC 60079-7	Gas/vapour (G)	–	Ex eb	Ex ec
	Optical radiation interlocked with optical breakage EN IEC60079-28	Gas/vapour (G) dust (D)	–	Ex op sh	+
Protection principle prevents an ignition source becoming effective.	Intrinsic safety Ex i EN IEC 60079-11 EN IEC 60079-25 systems	Gas/vapour (G) dust (D)	Ex ia	Ex ib	Ex ic
	Inherently safe optical radiation EN IEC 60079-28	Gas/vapour (G) dust (D)	Ex op is	+	+
Protection principle prevents the potentially explosive atmosphere reaching the ignition source.	Encapsulation Ex m EN IEC 60079-18	Gas/vapour (G) dust (D)	Ex ma	Ex mb	Ex mc
	Non incendive Ex nC Restricted Breathing Ex nR EN IEC 60079-15	Gas/vapour (G)	–	–	Ex nC Ex nR
	Liquid immersion Ex o EN IEC 60079-6	Gas/vapour (G)	–	Ex ob	Ex oc
	Pressurised enclosure Ex p EN IEC 60079-2	Gas/vapour (G) dust (D)	–	Ex pxb, pyb	Ex pzc
	Protection by enclosure Ex t EN IEC 60079-31	Dust (D)	Ex ta	Ex tb	Ex tc
	Protected optical radiation EN IEC 60079-28	Gas/vapour (G) dust (D)	–	Ex op pr	+
Protection principle prevents propagation of flames using an enclosure.	Flameproof enclosure Ex d EN IEC 60079-1	Gas/vapour (G)	Ex da	Ex db	Ex dc
	Powder filling Ex q EN IEC 60079-5	Gas/vapour (G)	–	Ex q	+

Table 5

\+ means: possible to apply
\- means: NOT possible to apply.

Application in hazardous area, depending either G or D

Zone 0/20	Zone 1/21	Zone 2/22
Zone 1/21	Zone 2/22	
Zone 2/22		

Types of protection to non-electrical equipment

Protection principles	Types of protection	Flammable material	Category 1 EPL a Very high level of protection	Category 2 EPL b High level of protection	Category 3 EPL c Normal level of protection
All	General requirements EN ISO 80079-361)/ EN IEC 60079-0[2]	Gas/vapour (G) dust (D)	+	+	+
Protection principle ensures that an ignition source cannot arise.	Constructional safety c EN ISO 80079-37[1]	Gas/vapour (G) dust (D)	Ex h	Ex h	Ex h
Protection principle prevents an ignition source becoming effective.	Control of ignition source b EN ISO 80079-37[1]	Gas/vapour (G) dust (D)	Ex h	Ex h	Ex h
Protection principle prevents the potentially explosive atmosphere reaching the ignition source.	Liquid immersion k EN ISO 80079-37[1]	Gas/vapour (G) dust (D)	Ex h	Ex h	Ex h
	Pressurised enclosure EN IEC 60079-2[2]	Gas/vapour (G) dust (D)	–	Ex pxb, pyb	Ex pzc
	Flow restricting enclosure EN 13463-2	Gas/vapour (G)	–	–	fr
	Protection by enclosure EN IEC 60079-31[2]	Dust (D)	Ex ta	Ex tb	Ex tc
Protection principle prevents propagation of flames using an enclosure.	Flameproof enclosure EN 13463-3 EN IEC 60079-1[2]	Gas/vapour (G)	– –	d Ex db	+ Ex dc

Table 6

[1] The EN ISO 80079-36 and -37 standards form in addition to the EN IEC 60079 series of standards a holistic set of technical standards for the development, testing and certification of explosion-proof non-electrical equipment.
[2] The standard for electrical devices is also applied to non-electrical devices.

\+ means: possible to apply
\- means: NOT possible to apply.

Application in hazardous area, depending either G or D

Category 1	Category 2	Category 3
Zone 0/20	Zone 1/21	Zone 2/22
Zone 1/21	Zone 2/22	
Zone 2/22		

Increased safety Ex eb according to EN IEC 60079-7

Principle

Additional measures provide a high level of protection "b". This ensures reliable prevention of unacceptably high temperatures and sparks or electrical arcs, both on the internal and on the external parts of electrical equipment whose normal operation does not involve unacceptably high temperature sparks or arching.

Applications

- Installation material such as junction boxes, connection technology for heating systems, batteries, transformers and cage motors.

Important design parameters

- For uninsulated, live parts, special protective requirements apply.
- Clearance and creepage distances are made wider than is generally the case in industry. Special requirements apply to the IP protection degree to be adhered to.
- For windings, their design, mechanical strength and insulation, higher requirements apply and the windings must be protected from increased temperatures.
- Minimum cross sections are stipulated for winding wire, the impregnation and reinforcement of coils and for thermal monitoring equipment.

Increased safety Ex ec according to EN IEC 60079-7 (previously non-sparking Ex nA according to EN IEC 60079-15)

Principle

A normal level of protection ‘c‘ is provided. The construction ensures reliable prevention of unacceptably high temperatures and sparks or electrical arcs, both on the internal and on the external parts of electrical equipment whose normal operation does not involve unacceptably high temperature sparks or arcing. Simplified version of type of protection eb.

Applications

- Installation material such as junction boxes, connection cabinets, rotating electrical machines, special fuses, luminaires, cells and batteries, transformers and semi conductor technology.

Important design parameters

- For uninsulated, live parts, special protective requirements apply.
- Clearance and creepage distances are specified.
- Special requirements must be fulfilled by certain types of equipment.

Constructional safety c with marking Ex h accordig to EN ISO 80079-37

Principle

The systems, equipment and components are constructed in a way which ensures that they cannot turn into an ignition source under normal operation or in cases of faults.

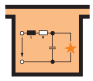
Applications

Coupling between pump and driving motor, fans.

Important design parameters

- Requirements to enclosure material are applicable identical as with the other types of protection
- The material choice must be selected in a way which ensures that their heating-up, for example by means of friction, is excluded.
- Friction occurring under normal operation is also not allowed to lead to electrostatic charging or frictional sparks.
- The constructive requirements - derived from EN 1127-1 - must be verified with regard to possible ignition sources.

Intrinsically safe Ex ia, ib, ic according to EN IEC 60079-11 (Ex ic = previous Limited Energy Ex nL according to EN IEC 60079-15)



Principle

Intrinsically safe circuits are circuits in which a spark or thermal effect occurring under the test conditions laid down in the standard is not able to ignite the explosive atmosphere of subgroups IIA, IIB and IIC or air/dust mixture of group III. The test conditions cover normal operation and certain fault conditions which are stipulated in the standard.

Applications

- Measuring and monitoring instrumentation and control.
- Sensors working on the basis of physical, chemical or mechanical principles and at limited power.
- Transmitters and remote I/O technology based on several fieldbus applications.
- Enterprise Mobility equipment like mobile computers, tablets, camera’s and smartphones.

Important design parameters

- Use of certain (unfallible) components for electrical and electronic circuits.
- Lower permitted load on the components than in ordinary industrial applications with regard to
  - voltage related to electric strength
  - current related to heat
- Voltage and current, including a safety margin, are kept permanently so low that no unacceptable temperatures can occur, and, in the event of open circuit or short-circuit, sparks and electric arcs possess so little energy that they are unable to ignite an explosive atmosphere.
- An impression of this type of protection is provided by the fact that explosive atmospheres of subgroup IIA require only a few 100 µJ and those of subgroup IIC only 10 µJ for ignition.

Control of ignition sources b with marking Ex h according to EN ISO 80079-37

Principle

Monitoring of possible ignition sources or early determination of dangerous conditions, such as heating up during normal operation, in malfunction or even rare malfunction, certain counter measures in critical situations are initiated.

Applications

- plain bearing, pump, agitator, vacuum pumps, gas turbines

Important design parameters

- Use of sensor/actuator devices to monitor various physical-technical variables (temperature, pressure, flow, speed, vibrations etc.)
- To limit the risk of ignition, an evaluation is done of the quality (function) of the ignition sources at the mechanical equipment and the corresponding sensor/actuator monitoring equipment.
- The functional reliability (minimum quality) of the sensor/actuator monitoring equipment is specified in the form of ignition prevention types.

Encapsulation Ex ma, mb, mc according to EN IEC 60079-18

Principle
Parts that could ignite an explosive atmosphere by means of sparks or heat are potted so as to prevent ignition of the explosive atmosphere. This is achieved by encapsulating (molding) the components in a casting compound, resistant to physical - especially electrical, thermal and mechanical - and chemical influences.

Applications
- Static coils in ballasts, solenoid valves, relays and other control gear of limited power and complete PCBs with electronic circuits.

Important design parameters
- Encapsulation:
  - Breakdown strength
  - Low water absorption
  - Resistance to various influences
  - Casting compound must be of the stipulated thickness all round
  - Cavities are only permitted to a limited extent
  - As a rule the casting compound is only penetrated by the electrical wiring entries
- The load on the components is limited or reduced
- Increased clearance between live parts

Non-incendive component Ex nC according to EN IEC 60079-15 (clause 7)

Principle
Variant of the Ex n type of protection with contacts which close and open a circuit potentially able to trigger an explosion, where the contact mechanism is designed in such a way that the ignition of a mixture of subgroup IIA, IIB or IIC in the surrounding environment is prevented as long as defined operating conditions apply.

Applications
- Contact systems

Important design parameters
- The contact arrangements will extinguish any incipient flame
- Limited maximum rating to 254 V and 16 A AC as well as DC
- L and C are part of the test
- Explosion subgroups IIA, IIB and IIC are to be treated differently.

Hermetically sealed device Ex nC according to EN IEC 60079-15 (clause 8)

Principle
The equipment may include cavities. It is constructed in such a way that the external atmosphere cannot enter.

Applications
- Spark generating equipment or components like interface relays.

Important design parameters
- Sealing by means of soldering, welding or fusion of metal to metal or glass to metal are considered as meeting the requirements for sealed devices without test.

Sealed device Ex nC according to EN IEC 60079-15 (clause 9)

Principle
The equipment may include cavities, which are fully enclosed similar to the encapsulation type of protection so that ingress of the outer atmosphere is prevented.

Applications
- Contact systems, static coils in solenoid valves and complete PCBs with electronic circuits.

Important design parameters
- Construction in such a way that it cannot be opened in normal operation.
- Internal free volume ≤ 100 cm³.
- Flying leads or terminals in type of protection Ex ec must be available as external connections
- It must not be possible for elastic seals to become mechanically damaged under normal operating conditions; they must maintain their sealing properties over the service life of the equipment.

Liquid immersion Ex ob, oc according to EN IEC 60079-6 (electrical equipment),

Liquid immersion k with marking Ex h according to EN ISO 80079-37 (non-electrical equipment)

Principle
Parts which might ignite an explosive atmosphere are immersed in oil or other non-flammable, insulating liquid so that gases and vapours above the oil level and outside the enclosure cannot be ignited by electric arcs or sparks generated below the liquid level, or by hot residual gases from the switching process or by hot surfaces - for example on a resistor.

Applications
- Large transformers, high power switchgear, starting resistors and complete starting controllers.
- Gearboxeswith electronic circuits.

Important design parameters
- Stipulated, insulating liquids, for example oil Protection of the liquid from contamination and moisture.
- Non-electrical equipment
  - Liquids
  - Wet surfaces (when partial immersed)
- Assurance and possibility of monitoring that the oil level is safe
  - When heated up or cooled
  - For identification of leaks
- Restricted to equipment for fixed installation only.

Pressurized enclosures Ex pxb, pyb according to EN IEC 60079-2

Principle

The ingress of the surrounding atmosphere into the enclosure of electrical equipment is prevented by maintaining a protective gas (clean dry air, inert or a different suitable gas) inside it at a pressure above atmospheric pressure. The overpressure is maintained with or without constant flushing of the protective gas.

Applications

- Equipment where during normal operation sparks, electric arcs or hot surfaces are generated and complex industrial equipment (controls) which must be operated in a potentially explosive atmosphere protected by this type of protection.
- Large machines, slip ring or collector motors, switch cabinets and control cabinets and analytical equipment.

Important design parameters

- Strength of the enclosure; the purged enclosure must withstand 1.5 times the overpressure experienced during normal operation.
- Purge (flush) before powering the electrical equipment (for EPL Gb only, so not for EPL Db).
- Mandatory shut-down and alarm for EPL Gb or Db if the purging gas flow or overpressure fails.

Pressurized enclosures Ex pzc according to EN IEC 60079-2

Principle

Use of a protective gas preventing ignition inside an enclosure to prevent the formation of an explosive atmosphere inside the enclosure by maintaining a pressure greater than the that in the surrounding atmosphere.

Applications

- Equipment where during normal operation sparks, electric arcs or hot surfaces are generated and complex industrial equipment (controls) which must be operated in a potentially explosive atmosphere protected by this type of protection.
- Large machines, slip ring or collector motors, switch cabinets and control cabinets and analytical equipment.

Important design parameters

- Strength of the enclosure.
- Purge flush before powering the electrical equipment (for EPL Gc only, so not for EPL Dc).
- Major difference to Ex pxb, Ex pyb: mandatory alarm only, if the purging gas flow or overpressure fails.

Restricted breathing Ex nR according to EN IEC 60079-15 for electrical equipment

Flow restrictive fr according to EN 13463-2 for non-electrical equipment

Principle

The enclosures are designed in such a way that the ingress of gases is restricted.

Applications

– Switchgear, measuring and monitoring instrumentation and information equipment (electrical).
– Luminaires (electrical).

Important design parameters

– The powerloss in the enclosure may, if it contains sparking components, only lead to a temperature increase on outside surface of ≤ 20 K compared to ambient temperature.
– Equipment with these enclosures must allow monitoring of the gas and vapour tightness , when brand new from factory as well as after installation and maintenance.
– It must not be possible for elastomeric seals to become mechanically damaged under normal operating conditions; they must maintain their sealing properties over the service life of the equipment.
– Cast seals must permit a continues operating temperature (COT) ≥ 10 K compared to the maximum service temperature.

Protection by enclosures Ex ta, tb, tc according to EN IEC 60079-31 (also applicable to non-electrical equipment)

Principle

The enclosure is sealed so tight, that no combustible dust can enter. The surface temperature of the external enclosure is limited.

Applications

– Various equipment where during normal operation sparks, electric arcs or hot surfaces occur and complex industrial designs (controllers) which by means of this type of protection can be utilised in the potentially explosive dust atmosphere.

Important design parameters

– Minimum degree of protection in accordance with EN IEC 60529 ≥ IP 5X or IP6X, depending on Group and level of protection
– Ex ta requiring supplementary IP 6X enclosures for sparking parts inside the overall equipment enclosure
– Consideration of dust accumulating on the surface and reduction of permissible surface temperature with dust layer ≥ 5 mm are applicable according to EN IEC 60079-14
– Surface temperature of the equipment is considered for Ex tb and Ex tc, where for Ex ta the surface temperatures of internal components is considered as well.

Flameproof enclosures Ex da, db, dc according to EN IEC 60079-1 for electrical equipment

Flameproof enclosures d according to EN 13463-3 for non-electrical equipment

Principle

A type of protection in which the parts which could ignite an explosive atmosphere are located inside an enclosure which can withstand the pressure of an explosion of the explosive mixture inside, and prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

Technically unavoidable gaps are so long and narrow that hot gases jetting out will have lost their power to cause ignition by the time they reach the outside of the enclosure, or, alternatively, if the gaps are only required for the manufacturing process they might be sealed with adhesive.

Applications

- Equipment where, during normal operation, sparks, electric arcs and/or hot surfaces are generated such as switchgear, slip rings, collectors, adjustable resistors, fuses, luminaires, heating elements, friction brakes.

Important design parameters

- Mechanical strength in accordance with a defined safety factor to withstand internal explosion pressure.
- As an orientation value, it may be assumed that inside a sphere approx. 0.8 MPa (8 bar) can be generated and that this sphere used as an Ex d enclosure must be able to withstand a pressure of 1.2 MPa (12 bar).
- Any gap between two parts of the enclosure must be kept so narrow and long that hot gas flowing out will not be able to ignite any explosive atmosphere which may be present in the potentially explosive atmosphere.
- The parameters for the gaps preventing the transmission of the ignition, gap width/ gap length, are different for the explosion subgroups IIA, IIB and IIC. The most stringent requirements with regard to the gap parameters apply to enclosures in explosion subgroup IIC.
- Ex d is in basis designed for level of protection ‘b‘, the additional level of protection ‘a‘ is applicable to catalytic sensors for combustible gas detectors only, just as level of protection ‘c‘ is applicable to enclosed break devices with internal volume limited to 20cm^3 = 0,02 liter.

Powder filling Ex q according to EN IEC 60079-5

Principle

By filling the enclosure with a finely grained powder from for example quartz glass, an arc within the enclosure is unable, with correct use, to ignite the explosive atmosphere outside. There must be no risk of ignition by flames, nor by increased temperatures at the surface of the enclosure.

Applications

- Capacitors, electronic assembly groups like HMI systems or even mobile computers which are used in a potentially explosive atmosphere. Often components where sparks or hot surfaces occur but whose functioning is not affected by the finely grained filling.

Important design parameters

- The filling such as sand, glass balls etc. has to fulfil specific requirements, as must the design of the enclosure. The filling must not be able to leave the enclosure, neither during normal operation, nor as the result of electric arcs or other processes inside the powder-filled enclosure.

Special protection Ex sa, sb, sc according to CLC/TR 60079-33 or IEC 60079-33

Principle
Devices which do not fully comply with a type of protection but assure comparable safety.

Applications
New developments like flameproof enclosures with explosion vents and pressure reduction grid plates in the side wall.

Important design parameters
Depending on which level of protection is required one or more independent verifiers are required to verify the compliance of the equipment. Further details see IEC 60079-33.

Optical Radiation Ex op is, op pr, op sh according to EN IEC 60079-28

Principle
Optical radiation can be either limited in radiation energy, or protected by a medium, or protected by an interlock.

Applications
Optical laser sensors, auto identification systems, fibre optic couplers for data transmission.

Design parameters
Three options:

- Lasers having convergent optical beams have to be inherent safe in energy when openly radiating in the hazardous area (Ex op is).
- When the laser goes through a medium like a fibre optic it can either be equipped with a mechanical protected system (Ex op pr) or
- by an interlock which has a safe guarding by a handshaking method. When transmitted output not being acknowledged by the receiver over the receiving line it will stop transmitting (Ex op sh).

Electrical Resistance Trace Heating Ex 60079-30-1 according to EN IEC/IEEE 60079-30-1

Principle
Safety requirements according to above mentioned standard. The marking is deviating from other types of protection by indicating on heating cables Ex 60079-30-1 as indication for the type of protection.

Applications
Winterization or Process Heating by the use of trace heating cables on piping or vessels.

Important design parameters
- Ex Trace Heating cable has to be equipped with an earthed braid.
- Temperature being limited in either a stablized design or a controlled design.

Marking

The marking on all equipment intended for use in potentially explosive atmospheres should provide all important information for safe operation. In addition, all information that is generally required for the same equipment in industrial design must be present.

Marking in accordance with Directive 2014/34/EU and EN standards

The requirements and assessments (incl. the marking) concerning electrical and non-electrical “equipment and protective systems intended for use in potentially explosive atmospheres” are uniformly defined in Directive 2014/34/EU. The marking of equipment and components is furthermore specified in the standards for general technical requirements (EN 60079-0 for electrical equipment or EN ISO 80079-36 for non-electrical equipment).

Accordingly, the overall marking on an ATEX equipment or component is made up of the require-ments under Directive 2014/34/EU and the requirements of EN standards. Both sources define the same requirements in some areas, which leads to redundant information on the identification label. It is impossible to estimate whether and when this duplicated information will be synchronized.

The following should be recognizable from the marking:

1. The manufacturer with name + address that has placed the equipment on the market
2. The type designation by which the equipment can be identified
3. The application area under ground Mining I or other surface areas II
4. The application area for gases and vapours (G), dusts (D) or mines (M)
5. The categories (1, 2 or 3) that state which safety level applies and whether the equipment may be used in certain zones
6. The type(s) of protection that the equipment satisfies
7. The group and the sub-group that the equipment is suitable for
8. The temperature class (G) or max. surface temperature (D) that the equipment complies with.
9. The equipment protection level (EPL in accordance with EN 60079-0 and EN ISO 80079-36) and the gases and vapours (G), dusts (D) or mining (M) application area that state whether the equipment may be used in certain zones
10. The specific conditions of use, where necessary, that must be followed, recognizable to an X either behind the certificate number (category 1 and 2) or behind the type of protection (category 3 when no voluntary Type Examination Certificate exists)
11. The type examination certificate with the Notified Body, the year of issue and the registration number of the certificate at the NoBo. for example PTB 20 ATEX 9999 X

In accordance with Directive 2014/34/EU the marking for all equipment will be as follows:

CE 0044 Ex II 2 G - gas/vapour
CE 0044 Ex II 2 D - dust

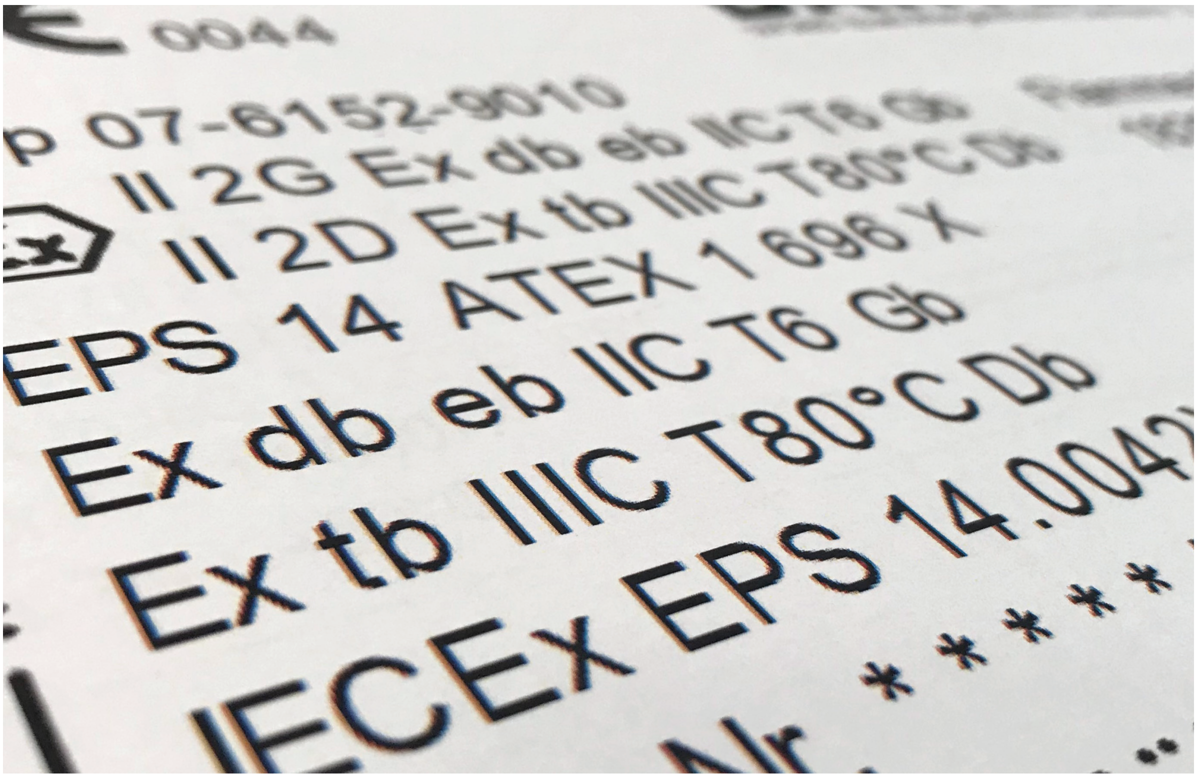
CE Conformity mark
0044 Notified Body who - if required - certified the QA system (for serial production) or the products (for unit verification)

Marking in accordance with IECEx System based on ISO or IEC standards

The international marking of the Ex Equipment and Ex Components is defined in IEC standards. The main points for marking and information are stipulated in the standards for the general technical requirement (IEC 60079-0 or ISO 80079-36) and the types of protection (IEC 60079 series or ISO 80079-37).

The following should be recognizable from the marking:

1. The manufacturer of the equipment
2. The type designation by which the equipment can be identified
3. The type(s) of protection that the equipment satisfies
4. The group and the sub-group that the equipment is suitable for
5. The temperature class (G) or max. surface temperature (D) that the equipment complies with
6. The equipment protection level (EPL in accordance with IEC 60079 series) and the gases and vapours (G), dusts (D) or mining (M) application area followed by a level of protection a, b or c, that state whether the equipment may be used in certain zones
7. The specific conditions of use, where necessary, that must be followed, recognizable to an "X" behind the Certificate of Conformity
8. The Certificate of Conformity with the IECEx Certification Body, the year of issue and the registration number of the certificate at the IECEx ExCB for example IECEx PTB 20.9999 X



Application areas – equipment categories – equipment protection levels

The following chart shows the designated areas of use of equipment and components according to equipment group and equipment category/equipment protection level.

Hazardous area			Equipment			
Conditions and subdivisions			Required marking on the usable equipment			
Flammable materials	Temporary behaviour of explosive atmosphere	Classification of hazardous areas	Equipment group as defined in directive 2014/34/EU	Equipment category as defined in directive 2014/34/EU	Equipment group as defined in EN IEC 60079-0 EN ISO 80079-36	Equipment protection level (EPL) as defined in EN IEC 60079-0 EN ISO 80079-36
Gases Vapours	Is present continuously or for long periods or frequently	Zone 0	II	1G	II	Ga
	Arises in normal operation occasionally	Zone 1	II	2G or 1G	II	Gb or Ga
	Is not likely toarise in normal operation, or if it does, will persist for a short time only	Zone 2	II	3G or 2G or 1G	II	Gc or Gb or Ga
Dusts	Is present in the form of a cloud continuously, or for long periods or frequently	Zone 20	II	1D	III	Da
	Occasionally develops into a cloud during normal operation	Zone 21	II	2D or 1D	III	Db or Da
	Is not likely to develop into a cloud during normal operation, or if it does, for a short time only	Zone 22	II	3D or 2D or 1D	III	Dc or Db or Da
Methane Carbon dust	Operation where there is a risk of explosion	-	I	M1	I	Ma
	Disconnection where there is a risk of explosion	-	I	M2 or M1	I	Mb or Ma

Table 7

Electrical equipment – gas/vapour and dust

Marking example in accordance with directive 2014/34/EU according to EN 60079 series and IECEx System according to IEC60079 series

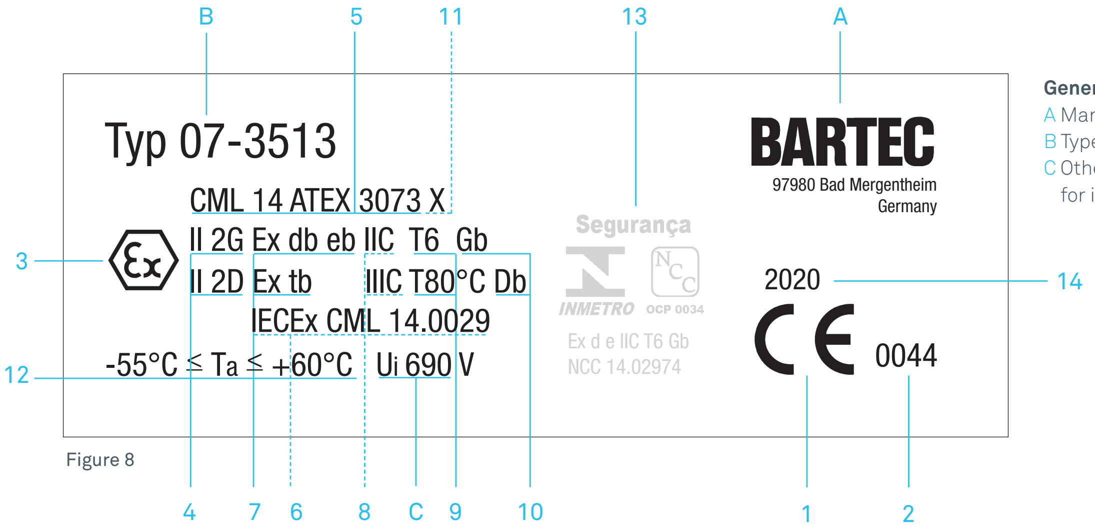


Figure 8

General manufacturer information
A Manufacturer name and address
B Type number of the product
C Other relevant information for industrial equipment

Information specific to explosion protection (marking)

ATEX directive and EN standards	IECEx System and IEC standards
1 Conformity mark (CE) 2 Identification number of the Notified Body which - where required - certified the QA system or examined the products (Category 1 and 2)	
3 Ex mark (community Epsilon x logo)	
4 Equipment group II - other areas (non-mining) Equipment category 2 either - gases/vapours G, suitable for Zones 1 and 2 or - dusts D, suitable for Zones 21 and 22 (see Table 7)	
5 EU-Type Examination Certificate Notified Body name or symbol, year and Notified Body's certificate registration number	6 IECEx Certificate of Conformity (CoC) Certification Body's symbol, year and Certification Body's certificate registration number
7 Explosion protection in compliance with EN 60079 series, Type of protection: flameproof enclosure and increased safety (gas) - marked Ex d and Ex e, protection by enclosure (dust) - marked Ex t all types of protection having high level of protection b	7 Explosion protection in compliance with IEC 60079 series, Type of protection: flameproof enclosure and increased safety (gas) - marked Ex d and Ex e, protection by enclosure (dust) - marked Ex t all types of protection having high level of protection b
8 Group IIC (most easy ignitable gases), Group IIIC (conductive dusts)	
9 Temperature class T6 (gas), max. surface temperature T80°C in absolute value (dust)	
10 Equipment protection level Gb (high protection level) (gas), equipment protection level Db (high protection level) (dust) (see Table 7)	
11 1. "X" observe Specific conditions of use: for example "the light module must be installed in a way that ensures its mechanical protection from impact energy in accordance with EN IEC 60079-0". 2. "U" Ex Component which is not intended to be used alone. Conformity is certified when installed into a complete operating equipment. Components don't have any temperature class.	
12 Ambient temperature range	
13 Marking in accordance with INMETRO (Example)	
14 Year of manufacture	

Non-electrical equipment – gas/vapour and dust

Marking example in accordance with Directive 2014/34/EU, according to EN/ISO 80079-36 and IECEx System according to ISO 80079-36)

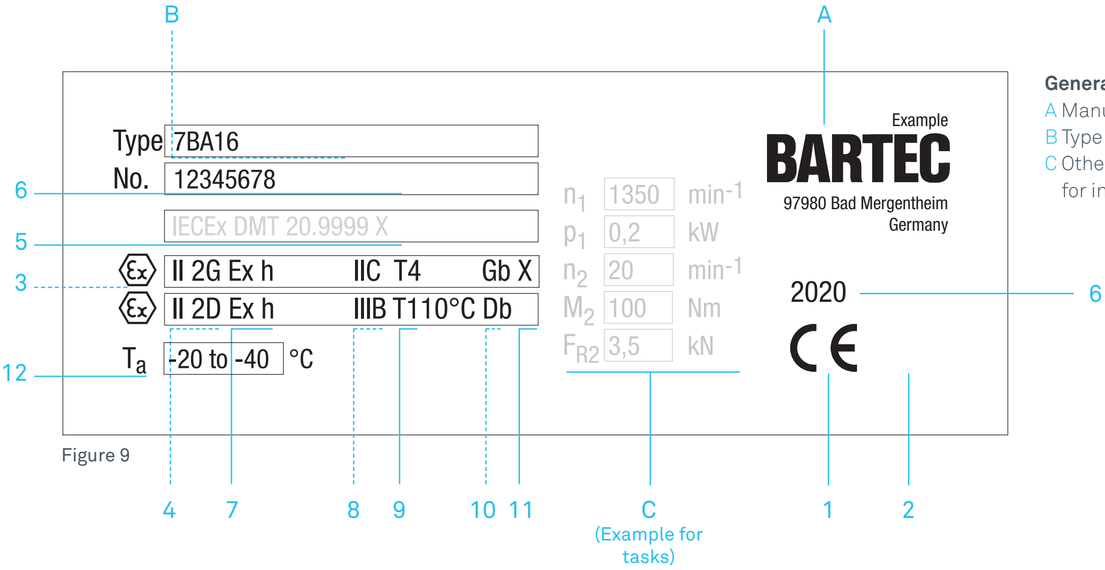


Figure 9

General manufacturer information
A Manufacturer name and address
B Type number of the product
C Other relevant information for industrial equipment

Information specific to explosion protection (marking)

ATEX directive and EN ISO standards	IECEx System and IEC ISO standards
1 Conformity mark (CE) 2 Identification number of the Notified Body which - where required - certified the QA system or examined the products * in this particular case not applicable	
3 Ex mark (community Epsilon x logo)	
4 Equipment group II - other areas (non-mining) Equipment category 2 either - Gases/vapours G, suitable for Zones 1 and 2 or - Dusts D, suitable for Zones 21 and 22 (see Table 7)	
5 EU-Type Examination Certification Notified body's symbol, year Notified body's registration number (only with Category 1 or on voluntary basis for Category 2)	5 IECEx Certificate of Conformity (CoC) Certification Body's symbol, year, Certification Body's certificate registration number (in IECEx Rules of procedure mandatory required for any EPL)
6 Year of manufacture	
7 Explosion protection in compliance with EN ISO 80079-36, -37 standards type of protection: constructional safety - marked Ex h	7 Explosion protection in compliance with ISO 80079-36, -37 Standards type of protection: constructional safety - marked Ex h
8 Group IIC (most easy ignitable gases), Group IIIB (non-conductive dusts)	
9 Temperature class T4 (gas), max. surface temperature T110°C in absolute value (dust)	
10 Equipment protection level Gb (high protection level) (gas), equipment protection level Db (high protection level) (dust) (see Table 7)	
11 1. "X" observe Specific conditions of use: for example The gearbox is to be installed only in certain position. 2. "U" Ex Component which is not intended to be used alone. Conformity is certified when installed into a complete operating equipment. Components don't have any temperature class.	
12 Ambient temperature range	

Conformity

Conformity Assessment Procedures and CE Marking to Directive 2014/34/EU

The conformity assessment procedures for “equipment and protective systems intended for use in potentially explosive atmospheres” are specified in Directive 2014/34/EU.

Depending on the equipment categories, the Directive stipulates which path the manufacturer must comply with up to preparation of the declaration of conformity. The following overview shows this path for the various conformity procedures.

Conformity Assessment Procedures

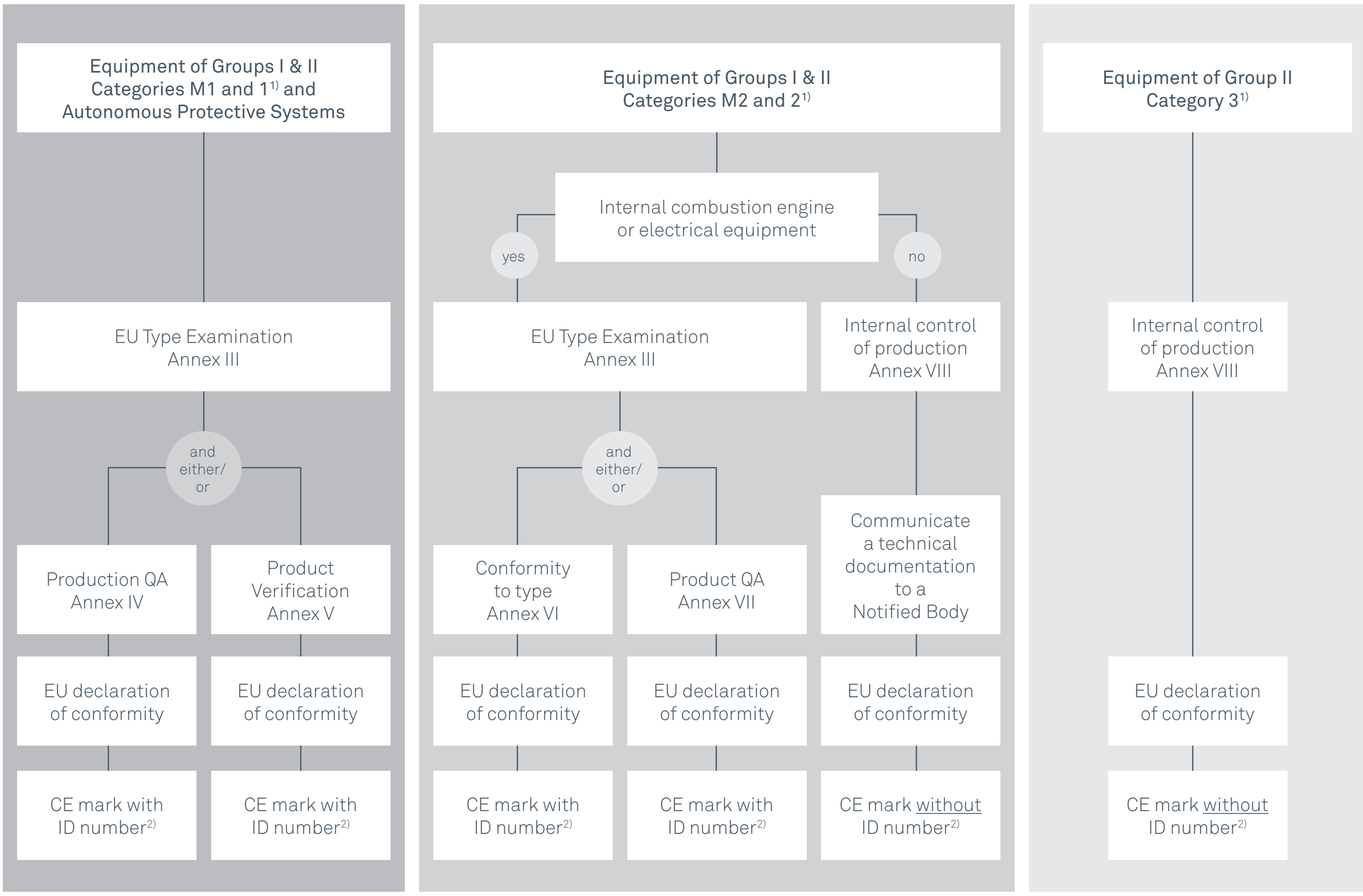


Figure 10

[1] and their components and equipment, if separately assessed.
[2] ID number of the Notified Body, which approved the QA system or verified the products.

Conformity in accordance with the IECEx System

The IECEx System stipulates Rules of procedure for checking and certifying equipment for use in Ex areas. All equipment must be tested by an IECEx ExTL (Ex Testing Laboratory) and certified by an IECEx ExCB (Certification Body), irrespective of the equipment protection level.

The result of the test is an IECEx ExTR (Test Report). The manufacturer must (for serial production) simultaneously have his quality management system checked and audited with a QAR (Quality Assessment Report) by an IECEx Certification Body. Having both an ExTR and a QAR is the basis for an IECEx CoC (Certificate of Conformity) in the online IECEx database. Alternative a so-called Unit Verification belongs also to the possiblities.

IECEx Certificate of Conformity (IECEx CoC)	Recognised quality management system (QAR)
Manufacturer applies to a certification body (ExCB) for an IECEx CoC for his product (all EPLs)	Manufacturer applies for a QAR at an ExCB
The ExCB checks and assesses the product i n a test laboratory (ExTL)	ExCB audits the manufacturer's Quality Management System
ExTL prepares a test report (ExTR) which will be validated by the ExCB and the ExCB checks the QAR (for serial production)	ExCB introduces a monitoring/surveillance system.
ExCB publishes the IECEx CoC in the IECEx online system	ExCB publishes the QAR report in the IECEx online system

Figure 11

ExCB (Ex Certification Body)
Subject to auditing, recognition; Issues ExTR, QAR and CoC

ExTL (Ex Testing Laboratory)
Subject to auditing, recognition; Checks compliance with the IEC or ISO standards

ExTR (IECEx Test Report)
Prepared by ExTL on the basis of uniform forms, approved by ExCB

QAR (IECEx Quality Assessment Report)
Issued by ExCB following the audit of the manufacturer's QMS (Quality Management System)

CoC (IECEx Certificate of Conformity)
Design corresponds to IEC standards (ExTR); Production takes place with recognised QMS (QAR) for serial production or Unit Verification Certificate for one off production

Comparison of ATEX and the IECEx System

Certification	ATEX Ⓔx Legally required in the EU		IECEx Voluntary in the EU Varying acceptance around the world
Testing and conformity of electrical equipment	Category 1 and 2:	Category 3	Equipment protection level (EPL a, b, c)
	– Recognized QA system – EU-Type Examination Certificate – EU Declaration of Conformity – CE marking	– Internal in-process inspection – Voluntary Type Examination Certificate – EU Declaration of Conformity – CE marking	– Quality Assessment Report (QAR) – Test Report (ExTR) – Certificate of Conformity (CoC) – Marking
Testing and conformity of non-electrical equipment	Category 1	Category 2[1] and 3	Equipment protection level (EPL a, b, c)
	– Recognized QA system – EU-Type Examination Certificate – EU Declaration of Conformity – CE marking	– Internal in-process inspection – Voluntary Type Examination Certificate – EU Declaration of Conformity – CE marking [1] Submission of the technical documentation to a Notified Body	– Quality Assessment Report (QAR) – Test Report (ExTR) – Certificate of Conformity (CoC) – Marking
Certificates	Manufacturer (often online)		IECEx online database
Repair workshops	No EU-certified workshops (regulated on a national level)		Certified Service Facilities
Service personnel	No EU-certified persons (regulated on a national level)		Certified competent persons
Zone classification	No EU-certified bodies (regulated on a national level)		Certified Service Facilities (under development)
Training Providers	No EU recognized training providers		Recognized Training Providers

Table 8

For further information on explosion protection
Please have a look at the Ex protection information section at www.bartec.de/safet-academy

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