Training Papers
Safety against explosion accidents

Contents

Part 1 What is an explosion: Introduction into explosion protection

What is an explosion? Introduction into explosion protection

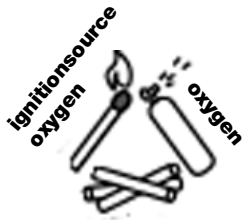
Introduction

When working with combustible materials, the presence of an ignition source entails the danger of an explosion. Its effect is uncontrollable, it might endanger people and destroy material values. Electric appliances and tools used in endangered areas, are potential sources of ignition. It is important to take measures to prevent the risk of ignition.

1 What is an explosion?

Definition: An explosion is a very rapid conversion of chemical or physical energy into kinetic energy with the occurrence of shock waves. There are two kinds of explosions:
physical explosion (e.g. explosion of a steam boiler - overheated steam)
chemical explosion (e.g. combustible gases or explosive substances, such as, TNT)
With an increasing rate of combustion, higher temperatures and higher pressure rising velocities will occur.

Three conditions have to be fulfilled for a explosion
oxygen



If only one component of the triangle is missing, no explosion can take place.

1.1 Oxygen

In our atmosphere, the air is composed of approx. 21% oxygen and approx. 79% nitrogen. If the percentage of oxygen is reduced to approx. 8% in the mixture of combustible material and air, no chemical reaction can take place. Conversely, the rate of combustion will be multiplied if the percentage of oxygen increases.

1.2 Combustible material

Combustible substances emit vapors and/or gases that burn when ignited or form explosive mixtures when contacted with air.
Not only known combustible substances, but materials, like flour, powder sugar, aluminium powder, plastic fibers, and heating fuel oil, may become very dangerous in a fine dispersion and/or at high temperature, in the form of dust and vapor.

1.3 Ignition sources

Possible ignition sources which ignite explosive mixtures and may thus cause explosions are, e.g.:

1.3.1 Hot surfaces

If an explosive atmosphere comes in contact with heated surfaces, an ignition may occur. The higher the temperature and the larger the surface of the heated body, the greater the chance of ignition.
Apart from surfaces which heat up in normal operation, such as radiators, mechanical processes, like friction, can lead to dangerous temperatures. Any moving parts such as bearings, shaft ducts etc. may become ignition sources if poorly lubricated.

1.3.2 Flames and hot gases

Flames are exothermal chemical reactions which run very rapidly at temperatures of approx. 1000°C and over. They are frequently accompanied by light phenomenon. Both the flames and the hot reaction products may ignite exlosive atmospheres. Even flames of very small dimensions count among the most effective ignition sources.

1.3.3 Mechanically produced sparks

Particles that are separated from solid materials by friction, such as impact and grinding can heat up to high temperature. Particularly with oxidizable substances, e.g. iron or steel, temperatures of well over 1000°C may be reached. These particles then become sparks. The formation of ignitable friction and blow sparks can be restricted by selecting suitable combinations of materials.

1.3.4 Electrical installations

When opening and closing electric circuits - even at low voltages - electric sparks, as well as hot surfaces may be come an ignition source. Breakage due to corrosion may form electric arcs or sparks. The surface temperature of an electrical appliance may rise continually.

1.3.5 Static electricity

As a consequence of friction, with at least one chargeable substance participating, ignitable discharges of static electricity become a concern under special conditions.

1.3.6 Electromagnetic frequencies and ultrasonics

With substances located in the radiation field, heating may come by internal friction. In extreme cases, the heating may even exceed the igniting
temperature.

1.3.7 Chemical reactions

Substances or systems of substances may heat up due to chemical reactions accompanied by the development of heat and thus act as an ignition source.

2 Safety characteristic numbers

2.1 Flash point

A very important safety characteristic number in explosion protection is the **flash point**. It is defined as the lowest temperature at which vapors develop from a liquid and may form a flammable mixture with air. When the ignition source is removed, the liquid stops burning. The flash point should be distinguished from the burning point which is higher and at which all the liquid is ignited.

2.2 Burning point

The **burning point** is the lowest temperature of a liquid at which the liquid burns upon being ignited. If the ignition source is removed, the liquid continues to burn.

2.3 Ignition temperature

The **ignition temperature** is the lowest determined temperature at which the combustible substance ignites spontaneously at atmospheric pressure. The ignition range is between a lower and an **upper limit of inflammability** (explosion limit). Below the **lower limit of inflammability** the concentration of combustible gases and vapors (in % by vol. or g/m_3) is too small (poor mixture) to cause burning or an explosion. Above the upper limit of inflammability the mixture is too rich in combustible parts (rich mixture) for an explosion to occur.

upper limit of inflammability (ULI)
lower limit of inflammability (LLI) (= lower explosion limit)

Part 2 Explosion protection

1 Primary explosion protection

If work is done in potentially hazardous locations, safety controls are indispensable.

Primary explosion protection means to prevent the formation of an explosive atmosphere, e.g. inside of appliances, by:

- replacing combustible substances by incombustible ones
- preventing the infiltration of air and oxygen (possibly working under inert gas)
- limiting the concentration of the combustible-air mixture outside the ignition
area

Moreover, ignition should be prevented, e.g. in the design of the appliances:

- by separating the ignition source from the explosive atmosphere
- by preventing ignition sources with proper design
- by proper ventilation (avoiding the increase of concentration of a combustible-
air mixture)
- by monitoring the concentration (e.g. with gas warning instruments)

As a rule, primary explosion protection cannot be ensured completely, in some cases not at all. It is necessary, to set up procedures to safeguard that dangerous explosive atmospheres cannot be ignited.
Explosion Protection Guidelines (in Europe: ATEX 95) rule the explosion pro-tection of equipment and protective systems in those cases where it comes into contact with an explosive atmosphere. Accordingly, the equipment and protective systems are subjected to a special regulation, being one of many potential ignition sources. The safety controls should be adapted to the probability with which the risk of an explosion in a work area can be expected.

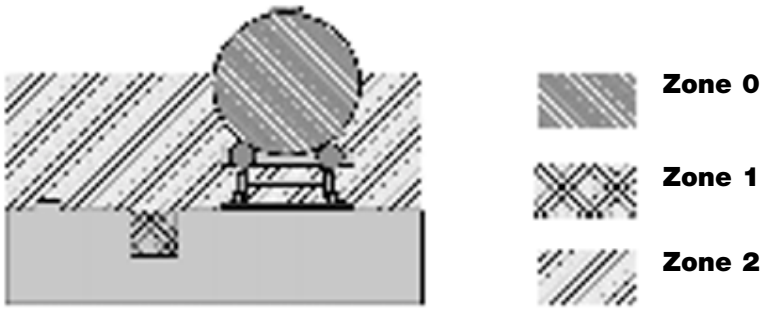
2 Classification of areas

2.1 Equipment group

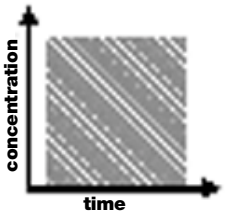
Explosion-proof equipment and protective systems are classified into two main groups I and II according to its application.
Equipment group I applies to equipment intended for use in underground pasts of mines.
Equipment group II applies to equipment intended for use in other places liable to be endangered by explosive atmospheres. The letter “G” specifies the explosive atmospheres caused by gases, vapours or mists whereas the letter “D” concerns to explosive atmospheres caused by dust.

2.2 Zones

Hazardous locations are classified into zones according to the probability which arises from a dangerous explosive atmosphere. The hazardous locations and the classification into Ex-zones are defined by the authority of protection of labor.
Since concentrations diminish with an increasing distance from the source of danger, the location relates directly to the classification of areas. The term „source of danger“ designates the location at which combustible gases,
vapors, mists and liquids form or leak, or where explosive mixtures might be formed.

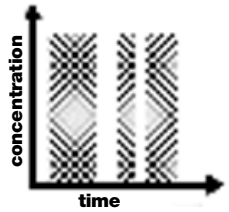


Zone 0
Category 1



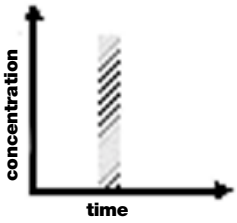
Constant or long-term existence of an explosive atmosphere with gases, vapors or mists.
As a rule, this only applies to the inside of vessels or apparatus (evaporators, reaction vessels, etc.), if the conditions of the definition of Zone 0 are meet.

Zone 1
Category 2



Occasional formation of an explosive atmosphere by gases, vapors or mists.
This may include, among others:
- the close proximity of zone O
- the close proximity of charging doors
- the close area around filling and emptying units
- the close area around easily breakable apparatus or lines of glass, ceramics, etc.
- the close area around insufficiently sealing stuffing boxes, e.g. at pumps and slides, the inside of apparatus like evaporators, reaction vessels.

Zone 2
Category 3



Only rare, on occasional, formation of an explosive atmosphere by gases, vapors or mists.
This may apply, among others:
- to areas surrounding zones 0 and 1, or areas around flange joints with plain coupler of conventional design for pipe lines in closed rooms.

Further zones are

Zone 10; areas where dangerous explosive atmospheres exist due to a high frequency of dust exposure for long periods of time.
Zone 11; areas where it is expected that occasionally a dangerous explosive atmosphere may occur for a short time by whirling up settled dust.
For clinical applications, zones G and M will apply instead of zones 0, 1 and 2.
In the following, we will only refer to zones 0, 1 and 2.

3 Gas group

The ignitability and disruptability of an explosive mixture is a substance-specific property. Requirements for the design of explosion-proof equipment can thus be graded depending on gases and vapors existing in the application area. For explosion group II, a classificaton into IIA, IIB and IIC has been made for type of ignition protection „d“ and „i“. For the flameproof enclosure“d“, it is based on the experimentally established maximum safe gap (MESG) or for intrinsically safe electrical equipment „i“ in the minimum igniting current (MIC).
All gases/vapors and mists are classified into explosion groups IIA to IIC. This permits a rapid assessment whether the equipment has been selected for the correct explosion group or for which explosion group the electrical appliance is rated. The danger of gases are rising from explosion group IIA to IIC. Accordingly, the requirements rise for an equipment regarding these explosion groups. Evidently, equipment and protective systems admitted for IIC can also be used for all other explosion groups.

Classification of gases and vapors into explosion groups and ignition temperatures of various substances according to EN

Ignition temperature in °C	Explosion group	Typical gases or vapors
540	**IIA**	acetone
515		ethane
425		ethanol
460		ethyl acetate
		ethyl nitrite
630		ammonia
630		aniline
555		benzene
365		butane
340		1, 2-butanol
505		methyl-ethyl-ketone
370		n-buthyl acetate
530		dichlorethylene
215		heptane
240		hexane
220-		300 fuel oil
595		methane
455		methanol
475		methyl acetate
210		octane
285		pentane
360		pentanol
		petroleum naphta
220-300		gasoline
470		propane
405		propanol
455		propylene
550		pyridine
490		styrene
535		toluene
385		vinyl acetate
415		vinyl chloride
		xylenes
140		acetaldehyde
605		carbon monoxide
425	**IIB**	ethylene
535		hydrogen cyanide
495		cyclopropane
180		diethyl ether
		tetrafluorethylene
		acetaldehyde
		(acroleine)
440		ethyl oxide
415		butadien-1,3
560		manufactured gases
430		propylene oxid
560	**IIC**	hydrogen
305		acetylene
		ethyl nitrate
95		carbon disulfide

4 Temperature classes

Appliances of Group II, have a classification regarding temperature classes T1 to T6 for all types of ignition protection in reference to the maximum admissible surface temperature for the appliance and the ignition temperature of combustible substances.

Temperature classes

Temperature classes	Max. admissible surface temperature of equipment °C	Constant admissible surface temperature of equipment	Ignition temperatures of combustible substances °C
T1	450	440	> 450
T2	300	290	> 300 < 450
T3	200	193	> 200 < 300
T4	135	130	> 135 < 200
T5	100	95	> 100 < 135
T6	85	80	> 85 < 100

5 Types of ignition protection

In order to safeguard against equipment and protective systems as an ignition source in potentially hazardous locations, the equipment is designed with a suitable ignition protection. The general regulations on the design and testing of this type of electrical appliance is described in Standard EN 50 014 (IEC 79-0) et seq.

Applications	Zones	Types of ignition protection acc. to EN Standards	Schematic diagram	Basic principle	Types of ignition protec-tion acc. to NEC
Switches, control and display units, control systems, motors, transformers, displays and any other spark-generating parts.	**1, 2**	**Flameproof enclosure „d“ EN 50 018 IEC 79/1**		Parts which may ignite an explosive atmosphere are housed in an enclosure capable of withstanding the pressure of the internal explosion of an ignitable mixture multiplied by 1.5 as security factor, and to prevent the transmission of the explosion to the atmosphere outside the enclosure.	**Explosionproof Enclosures**
as above, but mainly for large units including whole rooms.	**1, 2**	**Pressurized enclosure „p“ EN 50 016**		The infiltration of an explosive atmosphere into an enclosure with an electrical appliance is prevented by maintaining an inert gas (air, inert or other suitable gas) inside the enclosure at a higher pressure than that of the ambient atmosphere. The excess pressure is maintained with or without a continuous flushing with ignition-protective gas.	**Purging (for Class I) or Pressurizing (for Class II)** Remark: For purging there are three types (X, Y and Z) with diffe-rent control systems.
Measurement and control techniques	**0, 1, 2**	**Intrinsic safety „i“ EN 50 020 IEC 79/11**		The equipment used in the potentially hazardous location only comprises intrinsically safe circuits. A circuit is intrinsically safe due to the restricion of current and voltage if there are no sparks and no thermal effects which occur under established test conditions (covering normal operation and specific error/fault conditions) which can ignite a specific explosive atmosphere.	**Intrinsic Safety**

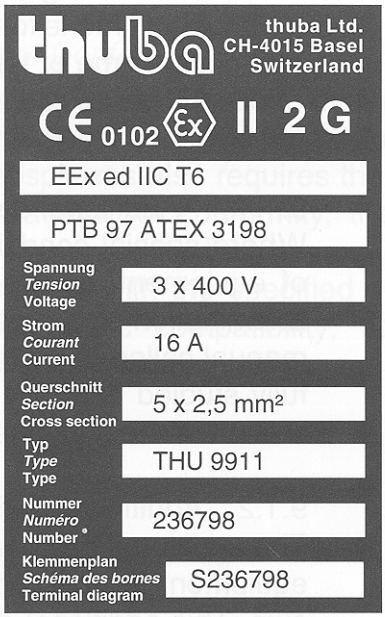
Applications	Zones	Types of ignition protection acc. to EN Standards	Schematic diagram	Basic principle	Types of ignition protection acc. to NEC
Transformers (rarely used now)	**1, 2**	**Oil-filled enclosure „o“ EN 50 015**		Electrical equipment or parts of electrical appliance are made safe by oil immersion to the effect that an explosive atmosphere above the surface or outside the enclosure cannot ignite.	**Oil Immersion**
Terminal and connecting boxes, control boxes for explosion-proof components (which are protected by another type of ignition protection), squirrel-cage motors, displays.	**1, 2**	**Increased safety „e“ EN 50 019**		Proceedings are made here to prevent, at a higher degree of safety, the possibility of inadmissibly high temperatures and the formation of sparks and arcs inside or on outside parts of electrical equipment, where these phenomena do not occur during normal operation.	**Unknown in the USA**
Transformers, capacitors, heating conductor connecting boxes (relatively seldom used)	**1, 2**	**Powder-filled enclosure „q“ EN 50 017**		By filling the enclosure of an electrical appliance with a finegrain substance it is ensured that an arc formed within the enclosure does not travel and ignite the explosive atmosphere surrounding the enclosure. Neither an ignition by flames, nor an ignition by increased temperatures can take place outside the enclosure.	”
Switches, control, display and signalling units, sensors	**1, 2**	**Encapsulation „m“ EN 50 028**		Parts which may ignite an explosive atmosphere are embedded into a sealing compound with sufficient resistance to guard against an explosive atmosphere or sparks or heat.	”
just as intrinsic safety	**0, 1, 2**	**Intrinsically safe systems „syst“ EN 50 039**		For intrinsically safe systems, the whole circuit is admissible with any equipment. Such systems comprise the equipment of the ignition protection „Intrinsic Safety“ described above, whose interconnection and installation are documented by a description of the system and approved.	”

Two categories „ia“ and „ib“ are differentiated in the ignition protection of Intrinsic Safety „i“. This designation has an influence on the application. Circuits installed within zone 0 may therefore only be included in category „ia“, and circuits for zone 1 and other areas in category „ib“.

Electical equipment for zone 0 and zone 1 is also suitable for zone 2. There is an additional ignition protection type (no sparkling) which can be used (EN 50021 / EN 50079-15)

6 Marking of explosion-proof equiments

Equipment and protective systems which are installed and operated in a potentially explosive atmosphere are subject for approval with the corresponding zones and should bear a special plate, in reference to the following data:



All equipment and protective system must be marked legibly and indelibly with the following minimum particulars:

- Name and address of the manufacturer
- CE marking
- Designation of series or type
- Serial number
- Year of construction
- The specific Ex Sign, followed by the symbol of the equipment and category
- The identification number of the Notified Body, which is monitoring the production quality assurance
- The complete Ex Marking, e.g. EEx de IIC, together with the temperature class

7 Documentation

Declaration of Conformity

The responsible company must supply a declaration of conformity, that the equipment and protective system is in compliance with the appropriate standards and the needed certificates of conformity are available. If further regulations are valid for the system, a single declaration of conformity has to be issued.

thuba®

Konformitätserklärung
Declaration of conformity
Déclaration de conformité
PTB 00 ATEX 1001

Wir / We / Nous,	thuba AG Postfach 431 CH-4015 Basel Switzerland
erklären in alleiniger Verantwortung, dass das Produkt *bearing sole responsibility, hereby declare that the product* déclarons de notre seule responsabilité que le produit	Temperaturregler und Sicherheitstemperaturbegrenzer Régulateur de température et limiteur de température de sûreté Temperature controllers and safety temperature cutouts KT . . . ..
auf das sich diese Erklärung bezieht, mit der/den folgenden Norm(en) oder normativen Dokument(en) übereinstimmt: *referred to by this declaration is in conformity with the following standards or normative documents* auquel se rapporte la présente déclaration est conforme aux normes ou aux documents normatifs suivants.	
Bestimmungen der Richtlinie *provisions of the directive* Désignation de la directive	Nr. und Ausgabedatum der Norm(en) *number and date of issue of the standard(s)* numéro et date d'émission de la(des) norme(s)
94/9 EG: Geräte und Schutzsysteme zur bestimmungsgemässen Verwendung in explosionsgefährdeten Bereichen 94/9 EC: Equipment and protective systems intended for use in potentially explosive atmospheres 94/9 CE: Appareils et système de protection destinés à être utilisés en emplacements dangereux	EN 50014:1997 EN 50018:1999-03 EN 50019:1999-03 EN 60529:1991-11 EN 1127-1:1997-10 EN 60079-14:1997-08 EN 60079-17:1997-08 EN 60730-1:1996-10 EN 60730-2-9:1995-11 VDE 0100 Teil 540:1991-11 VDE 0606 Teil 1:1998-12
89/336 EWG: Elektromagnetische Verträglichkeit 89/336 EEC: Electromagnetic compatibility 89/336 CEE: Compatibilité électromagnétique	EN 60947-1/A11:1994-11
Basel, 30. Mai 2000 Ort und Datum *Place and date* Lieu et date	Peter Thurnherr Geschäftsführender Direktor, Elektroingenieur HTL Managing Director, Electrical Engineer HTL Administrateur gérant, Ingénieur électricien ETS

The declaration of conformity must contain:

- Name and address of the manufacturer
- Description of the equipment or protective system
- The standards and regulations which are in compliance with
- Name and address of the Notified Body
- Person and Address of the person who has signed the declaration of conformity

Instruction Manual

All equipment and protective systems must be accompagnied by an instruction manual, at least the following particulars:

- A recapitulation of the information with which the equipment or protective system is marked
- Instructions for safe:
  - putting into service
  - use
  - assembling and dismantling
  - maintenance (service and emergency repair)
  - installation
  - adjustment
  - further aspects (see EC directive directly)

- Technical Data

8 IP degrees of protection provided by enclosures (IP Code, EN/IEC 60529)

The IP protection system consists of the letters ‚IP' and two numerals. The first numeral characterizes the protection against ingress of solid foreign objects, whereas the second characterizes the protection against harmful effects due to the ingress of water. The following IP codes are relevant for intended to use for explosion proof equipment:

Protection against ingress of solid foreign objects

4 Protection against ingress of solid foreign objects bigger than 1 mm (Contact with tools, wires etc.)

5 Complete protection against contact, protection against dust accumulation, but ingress of dust is not completely prevented (dust-protected)

6 Complete protection against contact and penetration of dust (dust tight)

Protection against ingress of liquids with harmful effects

4 Protection against splashing

5 Protection against jetting

6 Protection against powerful jetting

7 Protection against immersion under water with defined pressure for undefined time

8 Protection against immersion under water with increased pressure for undefined time

Part 3 Standards and regulations for equipment in potentially explosive atmospheres

Part 3

1 New EC directive 94/9 - ATEX

On March 1, 1996, a transitional period began for the implementation of the ATEX Directive (94/9/EC). This Directive applies to electrical and non-electrical equipment/components and protective systems intended for use in potentially explosive atmospheres. The ATEX Directive will become mandatory on July 1, 2003.
Equipment located outside potentially explosive atmospheres are also covered by the ATEX Directive under the following conditions:

- The equipment is a safety device, controller or regulatory device; and
- The equipment is required for the safe function of equipment or protective systems with respect to the risk of explosion.

All equipment under its scope will be required to bear the European CE Marking as verification of compliance with the Directive (the CE Marking will not appear on components defined by this Directive). The ATEX Directive specifically defines procedures for the evaluation of a product's design and manufacture (production) based on Equipment Groups and Categories. This is briefly outlined below.

Difference between the 'old approach' an the new ATEX regulation

It has a much wider scope and differs from the old approach directives in many ways. Some examples of this different approach are:

- CE marking is introduced and must be applied together with the specific explosion protection markings.
- Inclusion of non-electrical equipment
- Dust laden atmospheres are addressed.
- Harmonised European standards are no longer listed in the directive. Instead, a set of regulations are specified. CEN and CENELEC, the European standards making bodies have been tasked with the responsibility of preparing standards in support of these essential health and safety requirements.

- There is a modular approach to the conformity assessment of products. This gives manufacturers a choice of conformity assessment routes primarily split into two steps, a design stage and production stage.
- There is more emphasis placed upon the continued compliance of certified products. Conformity assessment addresses both the design and production phases. There is an option to adopt a quality systems approach to cover the production phase for some equipment. The quality systems will be based on the ISO 9000 series of standards but augmented for this purpose.
- The requirements for surveillance are addressed in more detail and are not therefore open to differing interpretations of the requirements.

All manufacturers of products covered by the ATEX directives are required to prepare a declaration of conformity containing details of the product, its intended use and how it has been demonstrated that it complies with the requirements of the applicable directives. In most cases, this will entail the involvement of a Notified Body in the Conformity Assessment Procedure.

2 Comparison USA/Europe

As compared to CELENEC member countries (EN standards), the type and criteria of zonal classification differs in the USA. Here, the corresponding regulations of the NEC (National Electrical Code) apply for electrical appliances and plants in potentially hazardous location.

	Class 1 Division 1 Group C+D
Class	Marking of the area of application
Division	Classification of the area of application
Group	Explosion group: classification according to explosion properties of the substances involved.

Classification into zones EN-NEC

	CENELEC (EN-standards)	USA (acc. to NEC)	
Gases, vapors and mists	**Zone 0 Zone 1 Zone 2**	**Class I**	**Division 1 Division 2**
Dusts	**Zone 10 Zone 11**	**Class II**	**Division 1 Division 2**
Fibers and fluff	**as for dusts**	**Class III**	**Division 1 Division 2**

In addition, a subdivision into Division 1 and Division 2 is current in the USA and in Canada. The comparison is outlined below.

Zonal classification EN-NEC

CENELEC (EN-standards)		USA (according to NEC)	
Zone 0	Areas where a dangerous explosive atmosphere exists constantly or for a long time (e.g. inside vessels, tanks, apparatus or pipelines).	**Class I Division 1**	Areas where dangerous explosive mixtures - exist under normal operating conditions - may occur frequently due to repair and maintenance work or to leakages - or areas where the failure or faulty operation of equipment or processes may cause the leakage of such mixtures with faulty electrical equipment present.
Zone 1	Areas where it has to be expected that a dangerous explosive atmosphere will form under normal operating conditions		
Zone 2	Areas where it has to be expected that a dangerous explosive atmosphere will form only seldom and then only at short times.	**Class I Division 2**	Areas - where combustible liquids or gases are contained in normally closed vessels or pipe systems from which they can only leak in case of failure (rupture or defect); - where dangerous explosive mixtures are normally prevented by ventilation, but failure or faulty operation of the ventilation can cause a risk; - leakage to an adjacent of Class I, Division 1, area of a dangerous gas or vapor mixtures must be prevented by ventilation and as such guarded against failure

The ignition temperature, i.e. the temperature at which an ignition by heat, from a hot surface may occur, it is dependent on the type of gases or vapors. This ignition temperature is affected by several factors and it is dependent on several factors. Different measuring methods, differ from country to country.

Classification of gases and vapors into explosion groups and ignition temperatures of these substances

The table below give a choice of gases and vapors of some industrial significance to compare the classification between Western Europe and the USA.

EN

Ignition temperature in °C test acc. to EN	Explosion Group	Typical gases or vapors
540	IIA	acetone
515		ethane
425		ethanol
460		ethyl acetate
		ethyl nitrite
630		ammonia
630		aniline
555		benzene
365		butane
340		butanol
		2-butanol
505		methyl-ethyl-ketone
370		butyl acetate
530		ethylene dichloride
215		heptane
240		hexane
220-300		fuel oil
595		methane
455		methanol
475		methyl acetate
210		octane
285		pentane
360		pentanol
		petroleum-naphta
220-300		petroleum (incl. gasoline)
470		propane
405		propanol
455		propylene
550		pyridine
490		styrene
535		toluene
385		vinyl acetate
415		vinyl chloride
		xylenes
140		acetaldehyde
605		carbon monoxide
425	IIB	ethylene
535		hydrogen cyanide
495		cyclopropane
180		diethyl ether
		tetrafluorethylene
		acroleine
440		ethylene oxide
415		butadiene-1,3
560		coke oven gas
430		propylene oxide
560	IIC	hydrogen
305		acetylene
		ethyl nitrate
95		carbon disulfide

USA

Group	Typcial gases or vapors	Ignition temperature in ° C test acc. NEC
D	acetone	465
	ethane	515
	ethanol	356
	ethyl acetate	427
	ammonia	651
	benzene	560
	butane	405
	1-butanol,	365/405
	methyl-ethyl-ketone	516
	n-buthyl acetate	425
	ethylene dichloride	413
	heptanes	280
	hexanes	225
	methane	539
	methanol	385
	octanes	220
	pentanes	260
	1-pentanol	300
	petroleum naphta	288
	gasoline	280-456
	propane	450
	1-propanol, 2-propanol	440/399
	propylene	460
	pyridine	482
	styrene	490
	toluene	480
	vinyl acetate	427
	vinyl chloride	472
	xylenes	530
C	acetaldehyde	175
	carbon monoxide	610
	ethylene	490
	hydrogen cyanide	
	cyclopropane	500
	diethyl ether	160
B	acroleine	220
	ethylene oxide	429
	butadiene	420
	manufactured gases	
	propylene oxide	449
	hydrogen	400
A	acetylene	305
special safeguards	carbon disulfide	100

A classification is made for several temperature classes to easily mark and select electrical appliances with regard to its maximum surface temperature.

Temperature classes (EN-NEC comparison)

EN standards temperature class	max. surface temperature °C	NEC temperature class	max. surface temperature °C	Ignition temperature of combustible substances °C
T1	450	T1	450	> 450
T2	300	T2	300	> 300
		T2A	280	> 280
		T2B	260	> 260
		T2C	230	> 230
		T2D	215	> 215
T3	200	T3	200	> 200
		T3A	180	> 180
		T3B	165	> 165
		T3C	160	> 160
T4	135	T4	135	> 135
		T4A	120	> 120
T5	100	T5	100	> 100
T6	85	T6	85	> 85

Marking of explosion-proof electrical appliance

Apart from current data (manufacturer, type/model, serial No., electrical data), the marking should entail the data concerning the explosion protection.

In the USA, explosion-proof electrical appliance to NEC 500-2 should bear the following data:

Class: Designation of the area of application (gas or vapor, atmosphere containing dust or fibres)
Division: Classification of the area of application
Group: Classification according to explosion properties of the substances for which the appliance is suitable

3 Types of Electrical Equipment Suitable for use in Potentially Explosive Atmospheres: Comparacy of Standards

Different techniques are used to prevent electrical equipment from igniting explosive atmospheres. There are restrictions on where these different types of equipment can be used as follows :

	European - Area of use Designation Standard	**IEC - Area of use Designation Standard**	**USA - Area of use Designation Standard**
Flameproof Enclosure – An enclosure used to house electrical equipment, which when subjected to an internal explosion will not ignite a surrounding explosive atmosphere.	Zones 1 & 2 EExd EN50018	Zones 1 & 2 Exd IEC60079-1	Class 1 Divisions 1 & 2 UL1203
Intrinsic Safety – A technique whereby electrical energy is limited such that any sparks or heat generated by electrical equipment is sufficiently low as to not ignite an explosive atmosphere.	Zones 0, 1 & 2 EExi EN50020	Zones 1 & 2 Exi IEC60079-11	Class 1 Divisions 1 & 2 UL913
Increased Safety – This equipment is so designed as to eliminate sparks and hot surfaces capable of igniting an explosive atmosphere.	Zones 1 & 2 EExe EN50019	Zones 1 & 2 Exe IEC60079-7	
Purged and Pressurised – Electrical equipment is housed in an enclosure which is initially purged to remove any explosive mixture, then pressurised to prevent ingress of the surrounding atmosphere prior to energisation.	Zones 1 & 2 EExp EN50016	Zones 1 & 2 Exp IEC60079-2	Class 1 Divisions 1 & 2 NFPA496
Encapsulation – A method of exclusion of the explosive atmosphere by fully encapsulating the electrical components in an approved material.	Zones 1 & 2 EExm EN50028	Zones 1 & 2 Exm IEC60079-18	
Oil Immersion – The electrical components are immersed in oil, thus excluding the explosive atmosphere from any sparks or hot surfaces.	Zones 1 & 2 EExo EN50015	Zones 1 & 2 Exo IEC60079-6	Class 1 Division 2 UL698