Europe

Explosion Protection to the European Standards

Basic Principals of Explosion Protection

Basic Principles of Explosion Protection

in accordance with the

European Standards EN 50014 - 50020

Basic Principals of Explosion Protection

The Europeans were the first to standardise on **ONE** common standard for the design and certification of apparatus for Potentially Hazardous Atmospheres.

The European standards EN 50014 to 50020 (28) were based on the IEC 79 recommendations and translated into **3** languages English, German and French.

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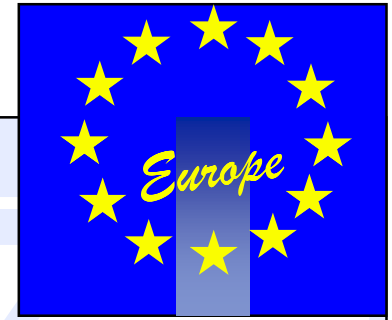

The major countries in Europe issued these standards in their own language and with their own numbers.

In Germany - VDE 0170 / 0171 - 1978

In England - BS 5501 Parts 1 - 7

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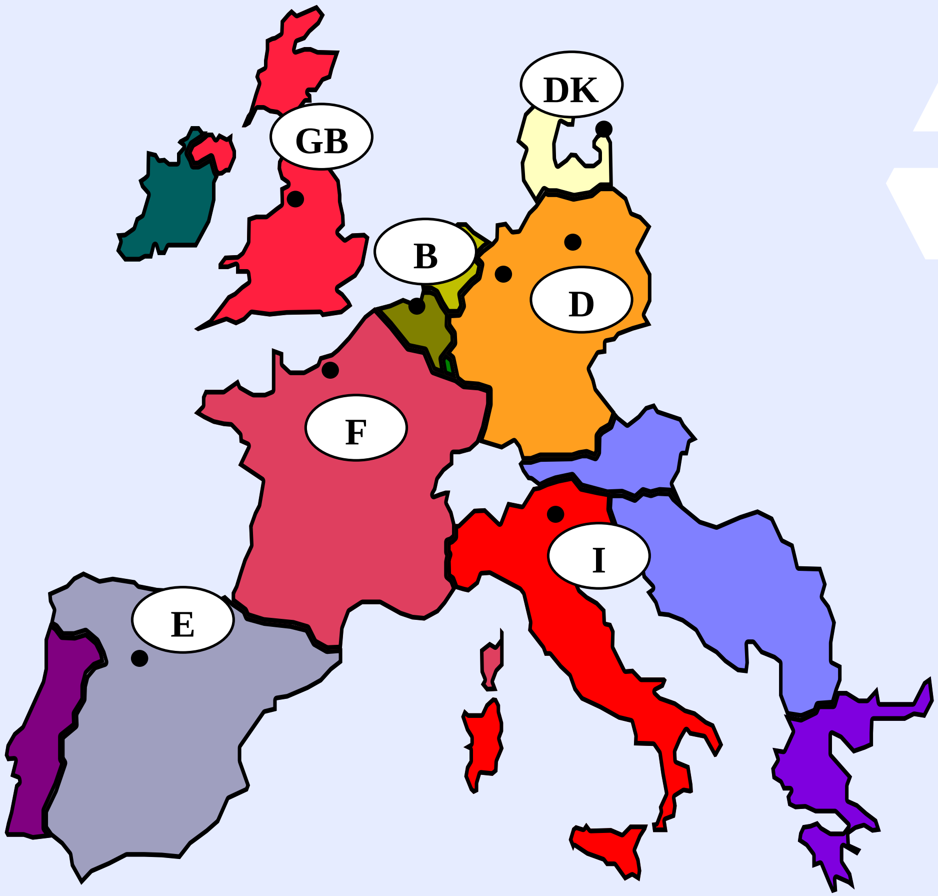
Selection of Approved CENELEC Testing Laboratories



DK	DEMKO
B	INIEX / ISSeP
D	PTB and BVS
I	CESI
GB	BASEFFA (EECS / SCS)
E	LOM
F	LCIE

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Definition of an explosion

An explosion is physically an exothermic - chemical reaction, commonly known as **Burning**, of combustible mixture of gasses, vapours or dusts and oxygen.

The result of which is a heat rise and an increase in pressure.

The combustion can occur at different speeds and forces depending on the nature of the mixture.

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Danger of Explosion

An explosion can occur when there is a

- Gas - Air mixture at a favourable proportion
- Dangerous volume
- Ignition source

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When is a Gas - Air mixture is a potential danger

Not all mixtures are a potential danger

- There is a minimum and maximum Gas - Air ratio at which combustion is possible
- Too weak - not enough gas to combust
- Too rich - not enough oxygen to allow burning

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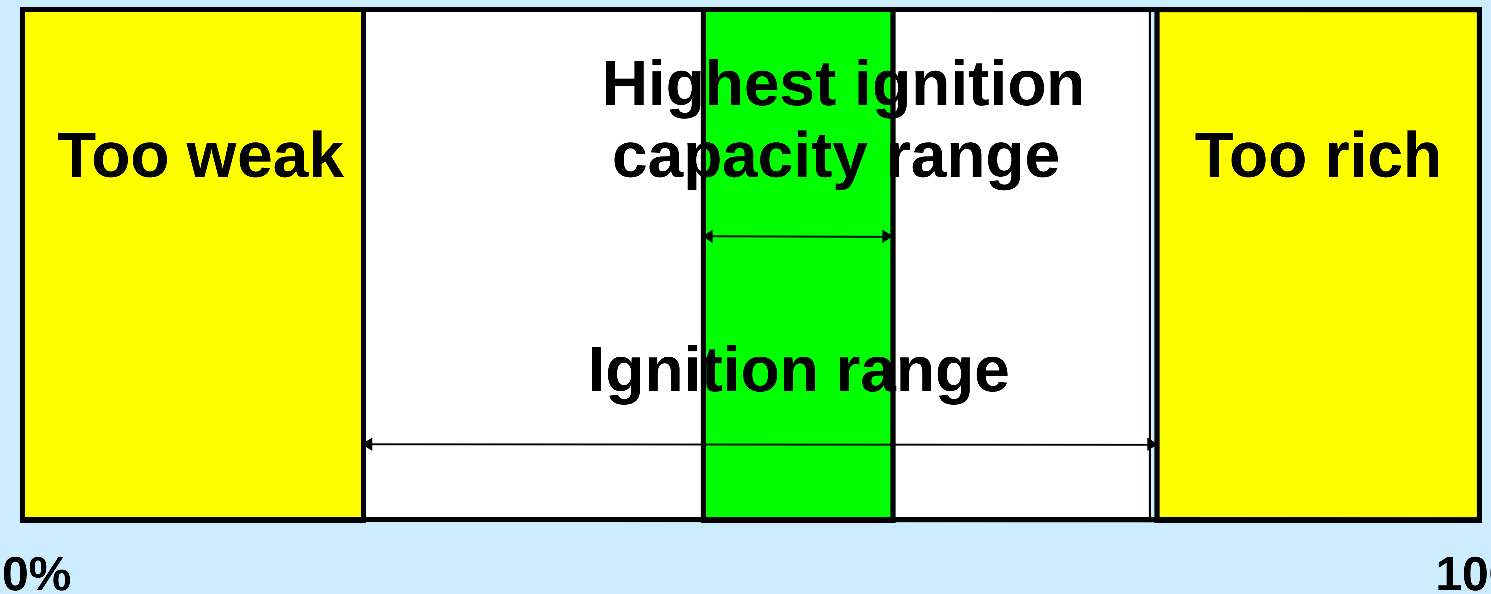

Town gas	6%	14%	20%	40 %
Hydrogen	4%	14%	34%	76%
Acetylene	1,5%	6%	12%	80%
Methane	5%	8%	9%	15%

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Ignition limits of gasses and vapors in air

Seq. No.	Combustible Material	Formula	Ignition Limit in Vol.%		Ignition Limit in g/m ³	
			Lower	Upper	Lower	Upper
1	Hydrogen	H_2	4.0	75.6	3	64
3	Amonia	NH_3	15.0	28.0	105	200
10	Methane	CH_4	5.0	15.0	33	100
17	Ethane	C_2H_6	3.0	15.5	37	195
33	Acetylene	C_2H_2	1.5	80.0	16	880
38	Propane	C_3H_6	2.1	9.5	39	180

(Extract from the manual “Raum-Explosion”)

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A mixture which lies between the upper and lower ignition limits will allow combustion with any ignition source.

Below the lower limit the weak mixture will not combust. Above the higher level, although burning can take place an explosion is impossible.

The nearer the mixture is to the highest ignition capacity range mixture ratio, the smaller the ignition energy required to ignite it and the higher the explosion power.

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Maximum Explosion Pressure

Starting at a mixture ratio at which even after 30 attempts no ignition would take place (weak mixture), the mixture is enriched at small increments and then ignited. The resulting pressure rise from the ignition is plotted on a graph.

It can be seen that the maximum pressure rise is normally 5 to 10 bar depending on the substance.

It was proved that highest pressure resulted at the point corresponding to the ratio at which the mixture was most volatile. This fact is important for the later explanation of gaps (Flamepaths).

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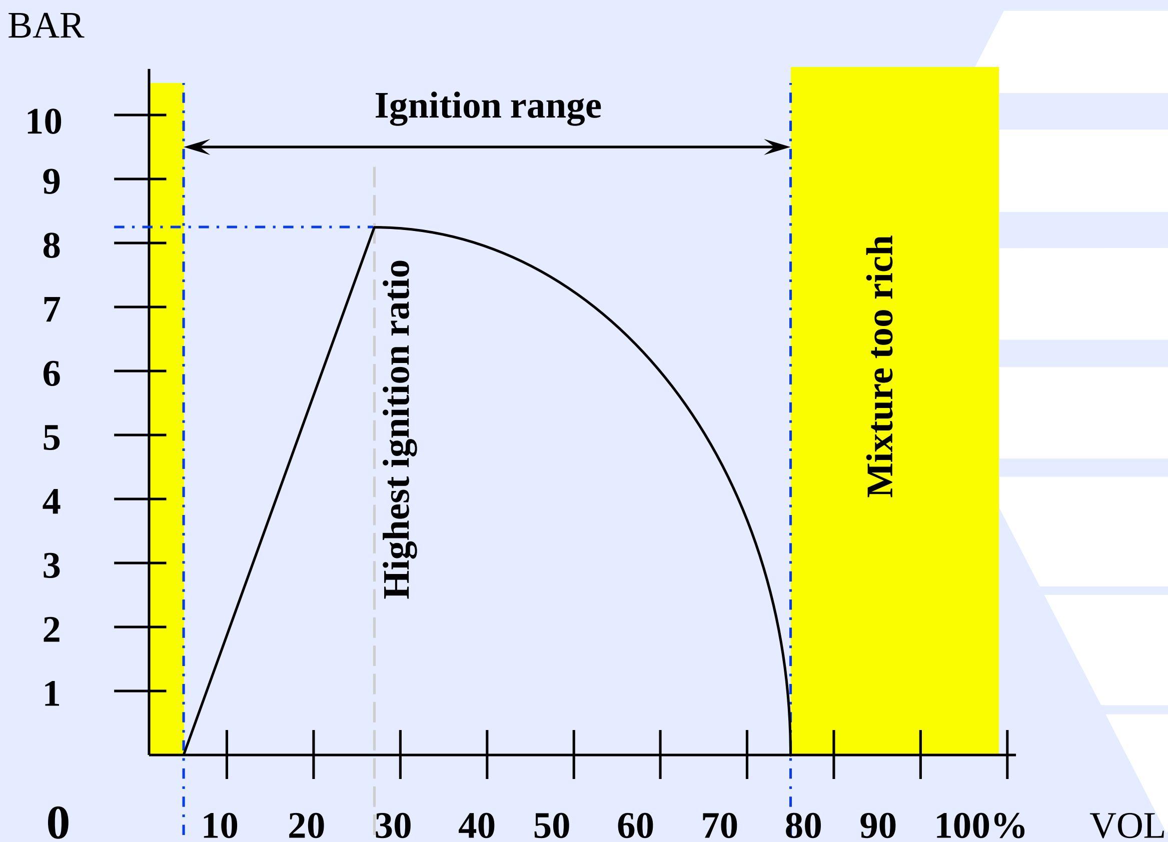

Maximum explosion pressure as a function of a Hydrogen - Air mixture

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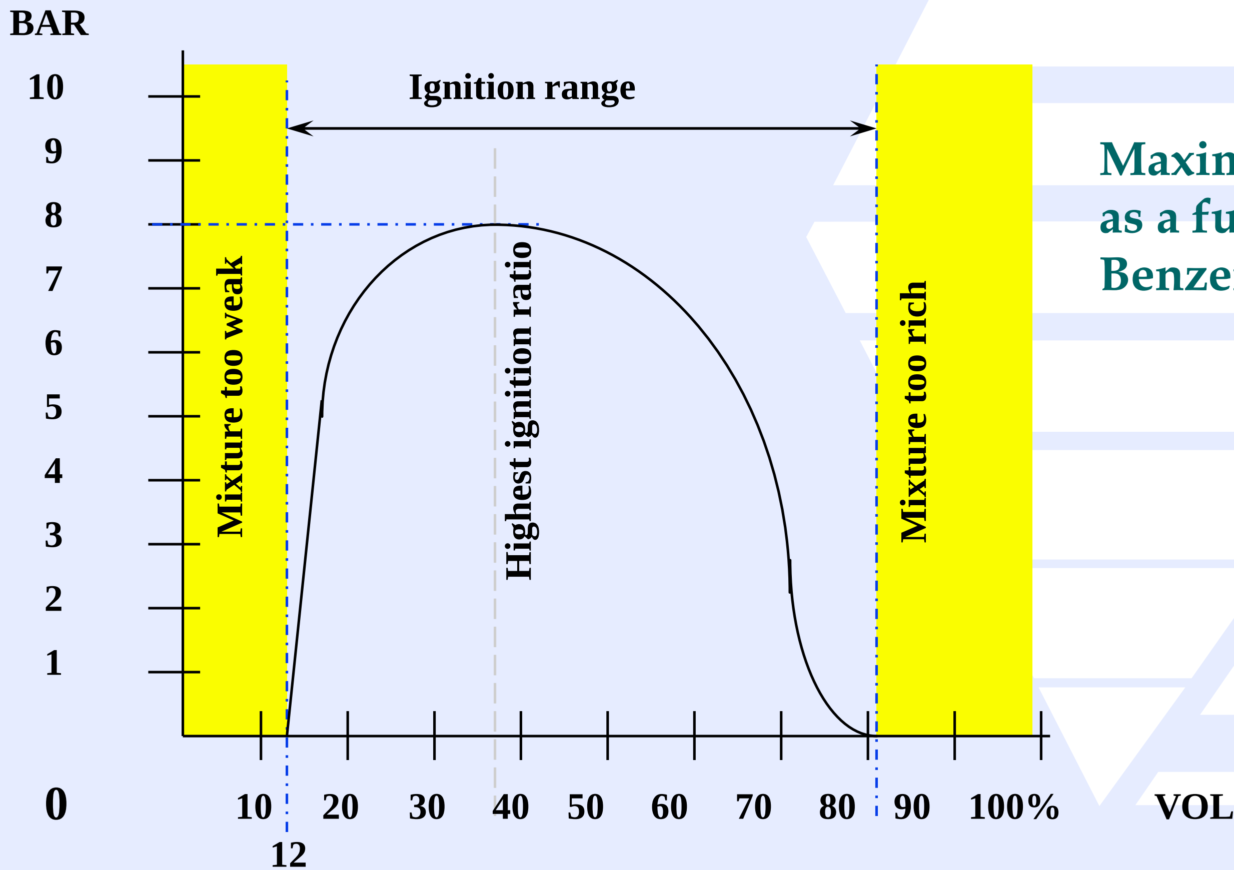

Maximum explosion pressure as a function of a Benzene - Air mixture

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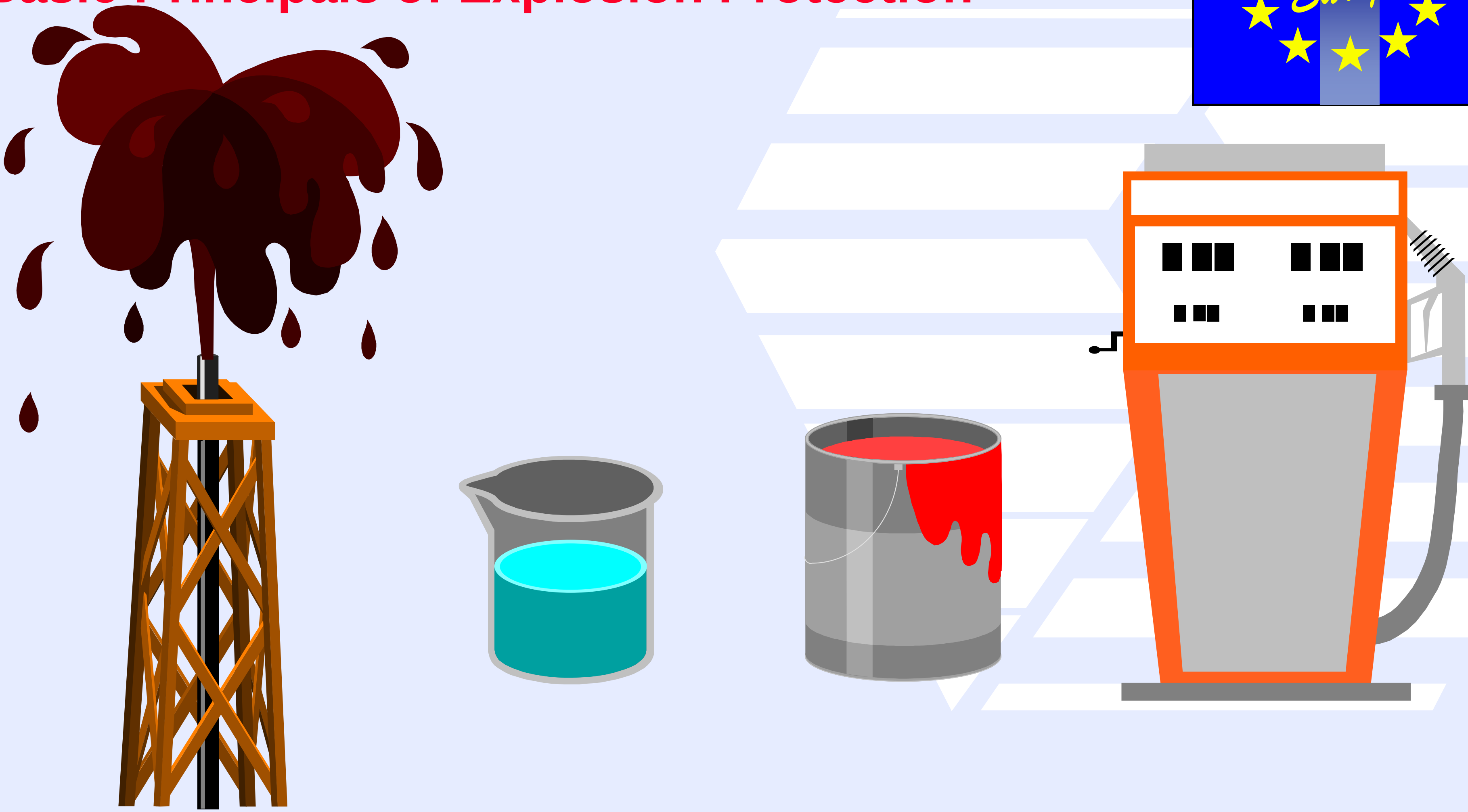

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Classification of Hazardous Areas

In order to stipulate the necessary protective measures required in a potentially explosive environment the areas are classified in respect of the probability of the occurrence of the explosive atmospheres.

The **IEC** and **EN** classification in to **3 Zones** or

the **NEC** classification in to **2 divisions**.

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The European standards are based on the **IEC** recommendation 79-10 which stipulates -

ZONE 0 - areas in which an explosive atmosphere is constantly present or can be expected for long periods of time

ZONE 1 - areas in which an explosive atmosphere can be expected occasionally for short periods of time during normal operation

ZONE 2 - areas in which an explosive atmosphere is only to be expected seldom, temporarily and only during a breakdown

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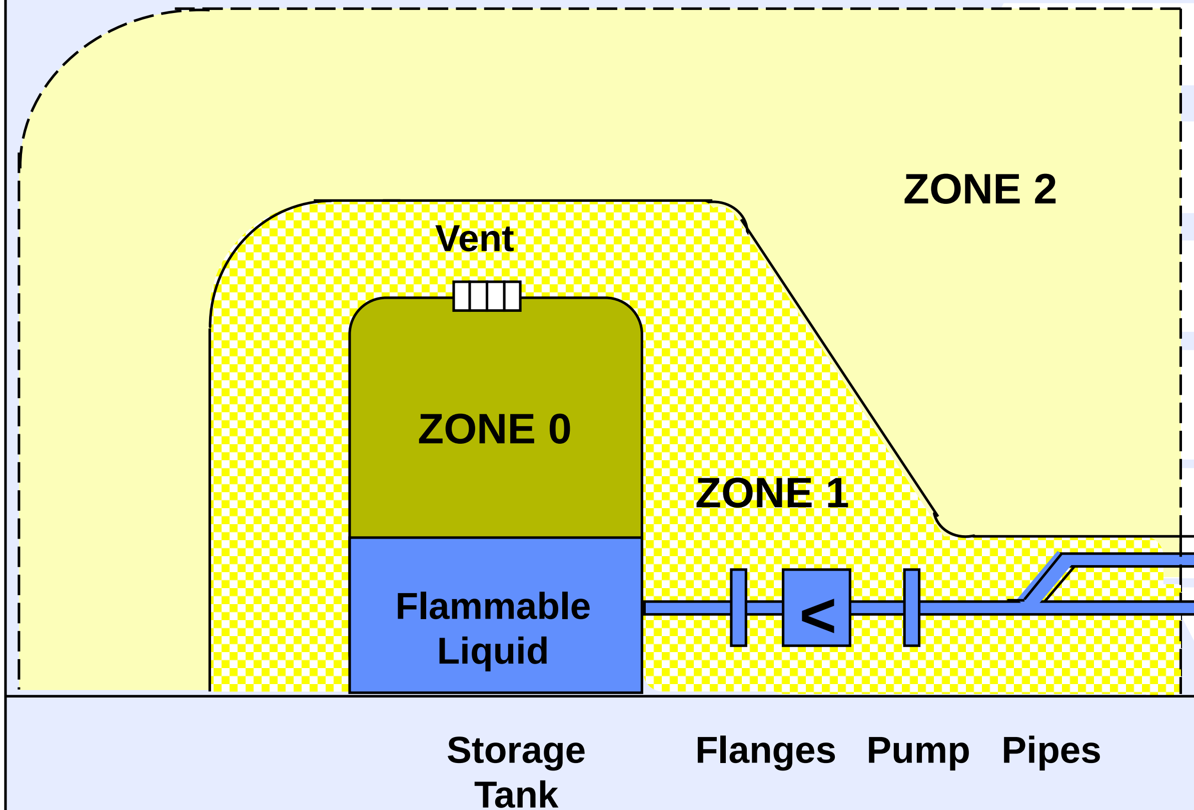
Classification of Hazardous Areas to IEC 79-10



Presence of explosive gas - air mixture

ZONE 0	Continuous or long periods
ZONE 1	Likely in normal operation
ZONE 2	Unlikely,only short periods

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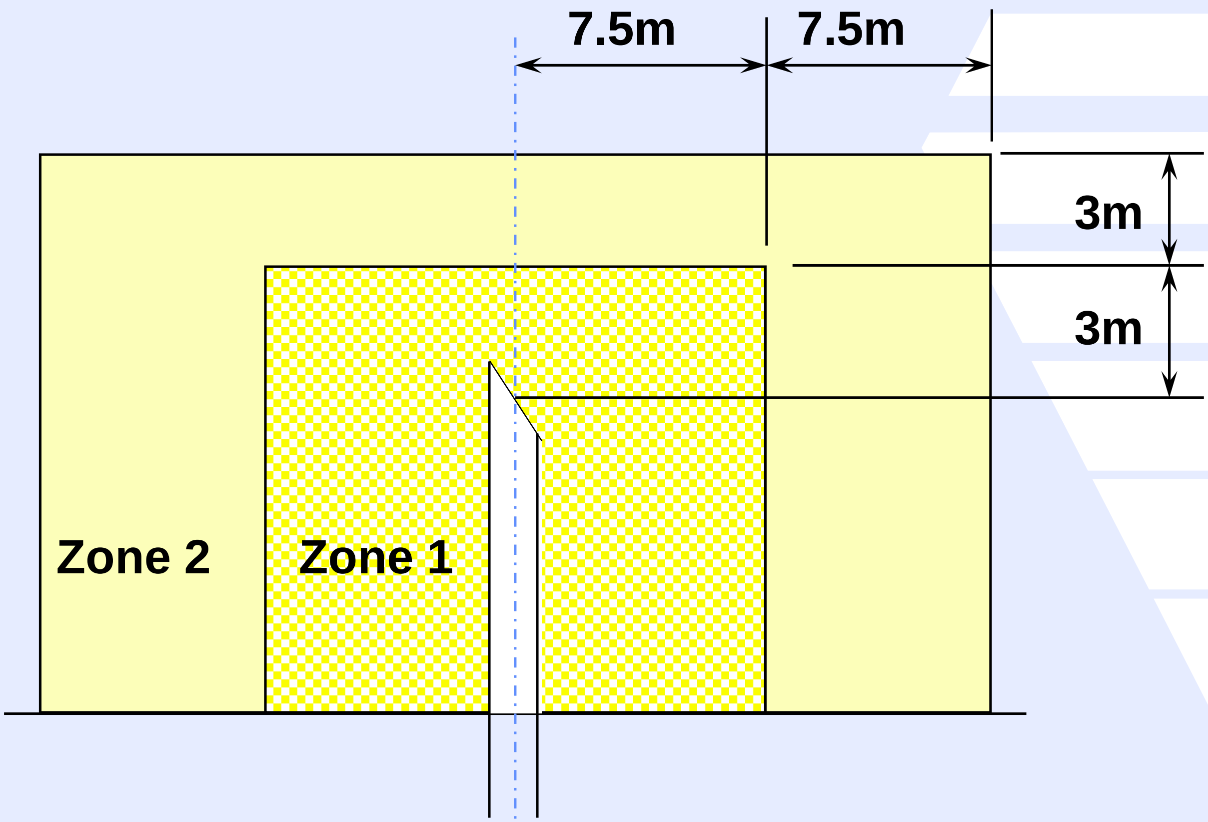
Examples of Zones



Area classification around source of hazard that is giving rise to explosive Gas-Air mixture during normal operation, outdoor location, heavier than Air gasses.

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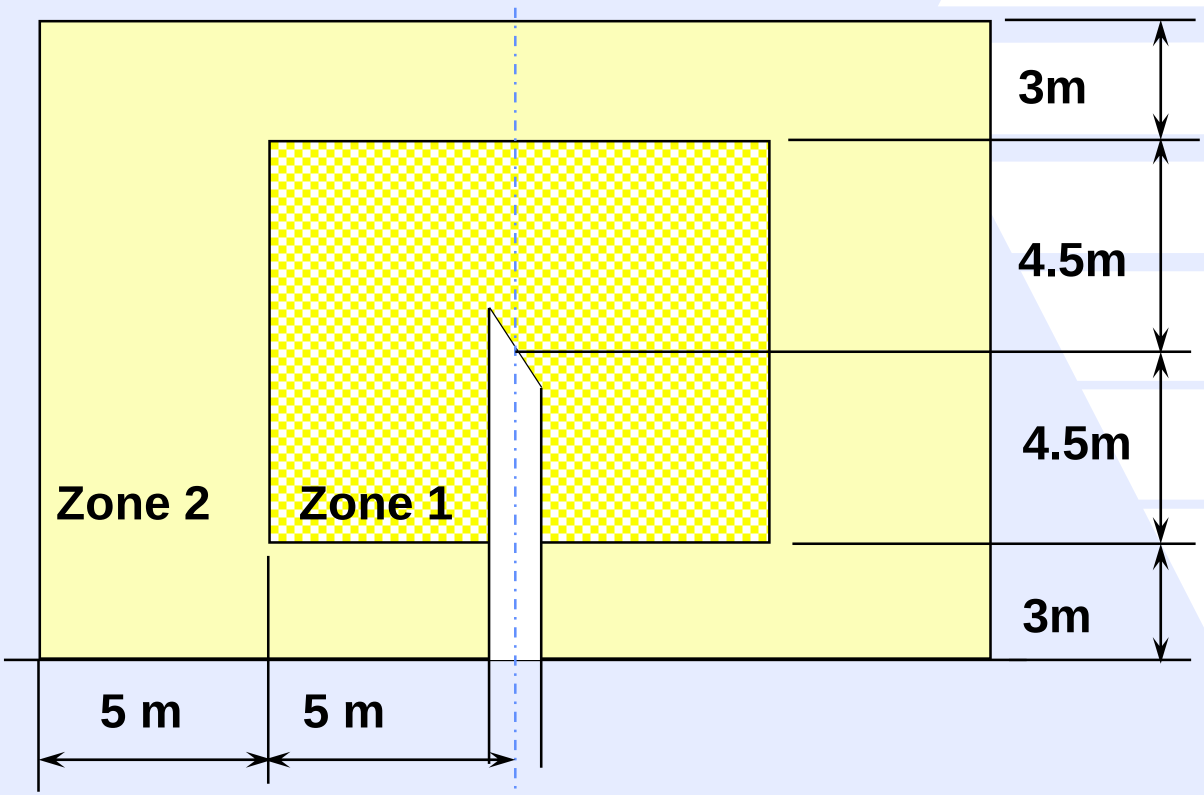
Examples of Zones



Area clasification around source of hazard that is giving rise to explosive Gas-Air mixture during normal operation, outdoor location, lighter than Air gasses.

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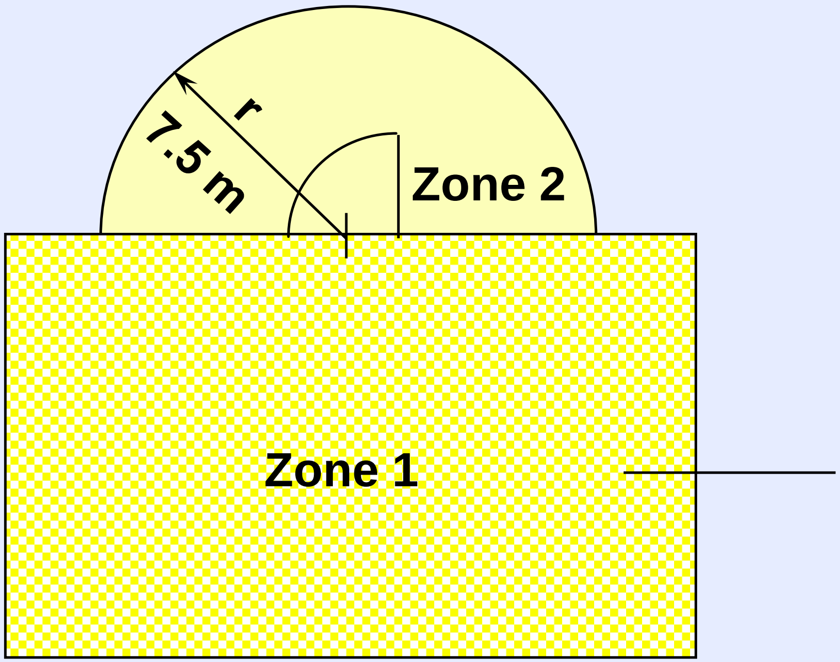
Examples of Zones



Enclosed building with inadequate ventilation

If the building is enclosed and contains a source of hazard that may cause a dangerous atmosphere in abnormal operating conditions, the interior of the building should be classified as Zone 1, heavier than Air gasses

Primary source of hazard

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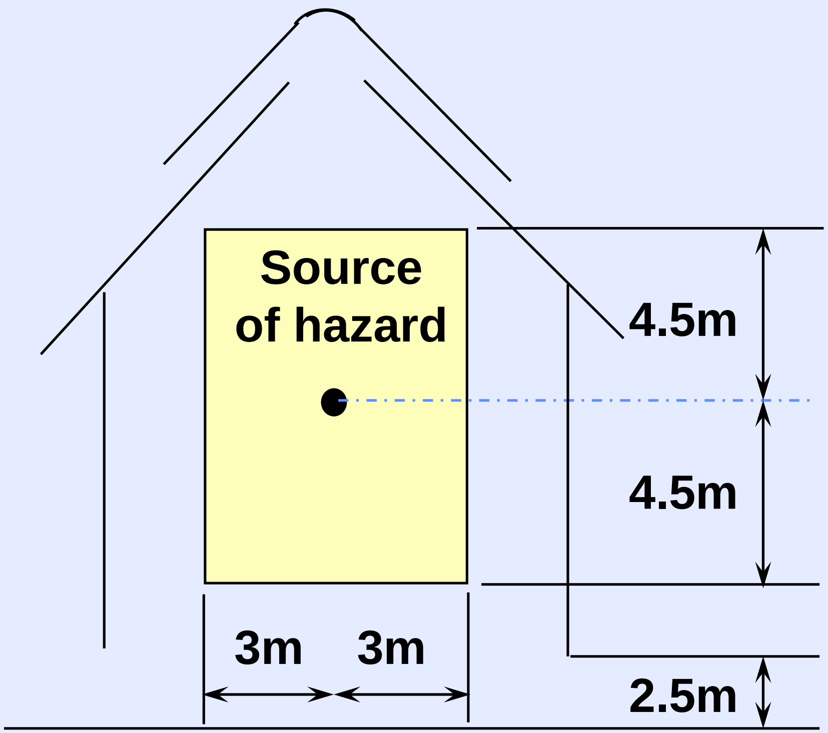
Examples of Zones

Open Buildings
Zone 2 areas



When necessary to extend side sheeting to ground level, the above classification may be retained, provided that louvres in the lower 2.5m have an open area excess of that in the roof, or mechanical ventilation is provided

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American NEC Standard

This classification which is still recognised in some other countries is subdivided only in to **2** divisions

Division 1- locations where flammable gasses or vapours may exist: under normal operating conditions, under frequent repair or maintenance operations, or where breakdown or faulty operation of process equipment might also cause simultaneous failure of electrical equipment.

Division 2 - locations where flammable gasses, vapours or volatile liquids are handled either in a closed system, or confined within suitable enclosures, or where hazardous concentrations are normally prevented by positive mechanical ventilation. Areas adjacent to Division 1 locations, into which gasses might occasionally flow, would also belong in Division 2.

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If the flammable mixtures are present often or for a comparatively long period of time, the electrical equipment used in that area must be given enhanced protection against the occurrence of explosions.

If, however, the flammable mixture occurs only seldom or temporarily in normal service, it would not be able to enter into the enclosed equipment in sufficient quantity to form an explosive atmosphere there and, in the case of apparatus which in itself does not represent an ignition source when used in accordance with the regulations, it is not necessary to allow for simultaneous occurrence of an explosive atmosphere and a fault that turns the equipment into an ignition source. Such considerations and similar led to the classification of the hazardous areas and subsequently the basic types of explosion protection.

Basic Principals of Explosion Protection

Types of Explosion Protection

- Primary Explosion Protection
- Secondary Explosion Protection

Basic Principals of Explosion Protection

Primary Explosion Protection

Prevention of a danger is always better than any protection from the danger.

Primary explosion protection is the prevention of the formation of an Explosive atmosphere, or the prevention of its ignition by

- Avoidance of the use of flammable materials
- Limiting its concentration by natural or artificial ventilation
- Changing its structure with additives to make it non combustive

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Secondary Explosion Protection

We assume however that the prevention of an explosive atmosphere is not possible so we have to take other types of precaution to avoid an ignition.

An explosion can only take place when three elements are available simultaneously :

- Combustible material
- Oxygen (21% of our air is Oxygen)
- Ignition source

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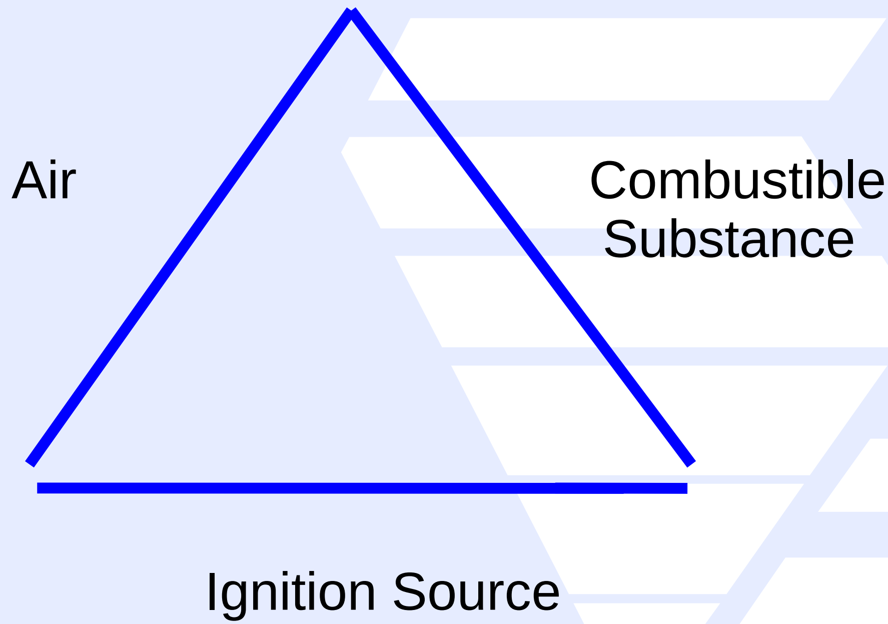
Basic Principals of Explosion Protection

The Hazard Triangle



Remove any one element and there is no danger.

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Basic Principals of Explosion Protection

As we must assume that we have the hazardous material due to the process and that Oxygen is always present, the only element we can eliminate is the ignition source.

The fundamental types of ignition source are -

- **HEAT** - open flames, hot surfaces, hot gasses, compressed gasses, sunlight, infra-red light, ultrasonic waves
- **ELECTRICAL SPARKS** - opening and closing of contacts, short circuits, over voltages (lightning), static discharge
- **MECHANICAL SPARKS** - friction, hammering, grinding

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We have now discovered when an atmosphere is potentially hazardous and to what extent.

We have seen what we must do to avoid an explosion.

Now forgetting the source of ignition by mechanical means we concentrate on the selection of electrical apparatus which will not cause ignition by either **HEAT** or **ELECTRICAL SPARKS**.

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CLASSIFICATION OF ELECTRICAL APPARATUS INTO GROUPS AND CLASSES

It is not economical and sometimes impossible to construct all electrical apparatus in a manner that it will meet the maximum requirements irrespective of its application. Also, because of the design of the apparatus, it is not always possible to use the same method of design to achieve protection against an ignition source.

Therefore apparatus is divided up according to its suitability into different groups and temperature classes.

Explosion Groups

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The European Standards have firstly divided the apparatus into

- **GROUP I** - for mines
- **GROUP II** - for all remaining potentially explosive atmospheres

At **CEAG** we have specialised in apparatus for **GROUP II**

The European Standards then divided the various flammable materials into **EXPLOSION GROUPS** and **TEMPERATURE CLASSES**

Basic Principals of Explosion Protection

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EXPLOSION GROUPS

The division of flammable materials into explosion groups was determined by one of two methods

- Mechanically - by means of the Maximum Experimental Safe Gap **MESG**
- Electrically - by means of the Minimum Ignition Current **MIC**

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Maximum Experimental Safe Gap MESG

Explosion Group	Flame Propagation at	Gas Group
A	> 0,9 mm	Methane
B	> 0,5 mm < 0,9 mm	Ethylene
C	< 0,5 mm	Hydrogen

This method of grouping is the basis of the type of protection Flameproof Enclosure - Exd

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Minimum Ignition Current MIC

Explosion Group	Ignition at	Gas Group
A	> 0,8	Methane
B	> 0,45 < 0,8	Ethylene
C	< 0,45	Hydrogen

This value is not a current but the relationship of the minimum ignition current required to ignite the mixture in comparison to the minimum ignition current required to ignite laboratory methane. This method of grouping is the basis of the type of protection Intrinsic Safety Ex i

Temperature Classes

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IGNITION TEMPERATURE

The ignition temperature of a flammable substance is the lowest temperature at which the ignition of that substance when mixed with air can be observed using the prescribed testing method.
The internationally recognised method is specified in IEC Publication 79-4 (DIN 51794) and is used by the European Standards to determine the ignition temperatures of all flammable mixtures.
These flammable substances have then been subdivided into 6 temperature classes **T1** to **T6**

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Now all flammable substances have been subdivided into both their

Explosion Groups GROUP I
or GROUP II sub divisions A
B
C

and Temperature Class T1
T2
T3
T4
T5
T6

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Classification of maximum Surface Temperatures for Group II Electrical Apparatus

Temperature class	Max. Surface Temperature °C	Ignition Temperature of Combustible Material °C
T1	450	> 450
T2	300	> 300
T3	200	> 200
T4	135	> 135
T5	100	> 100
T6	85	> 85

Classification of a selection of gasses and vapours in their Explosion Groups and Temperature Classes

	T1	T2	T3	T4	T5	T6
I	Methane					
IIA	Acetone, Ethane, Ethyl acetate, Ammonia, Benzene (pure), Acetic acid, Carbon monoxide, Methanol, Propane, Toluol	Ethyl alcohol, i-Amyl acetate, n-Butane, n-Butyl alcohol	Petrol, Diesel, Aircraft fuel, Heating fuel, n-Hexane	Acetylehyde, Acetic ether		
IIB	Town gas (Leuchtgas)	Ethylene				
IIC	Hydrogen	Acetylene			Carbon disulphide	Ethyl nitrite

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Types of Protection

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TYPES OF PROTECTION

Due to the nature, size and design of electrical apparatus there are a number of ways which they can be designed to avoid ignition.
There are basically **7** known and approved methods of which 1 or more may be applied to make apparatus safe.
The requirements for each type of protection are given in the standards.
Some are sufficient on their own, and some need added protection given by auxiliary apparatus.

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Type of protection “Flameproof Enclosure” Exd

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Flameproof Enclosure "d" is a type of protection in which the parts which can ignite an explosive atmosphere are placed in an enclosure which will withstand the pressure developed during an internal explosion of an explosive atmosphere and which prevents the transmission of the explosion to the explosive atmosphere surrounding the enclosure.

This is the most used type of protection as nearly all types of apparatus which cause arcs, sparks or dangerous surface temperatures are built in the type of protection flameproof enclosure.

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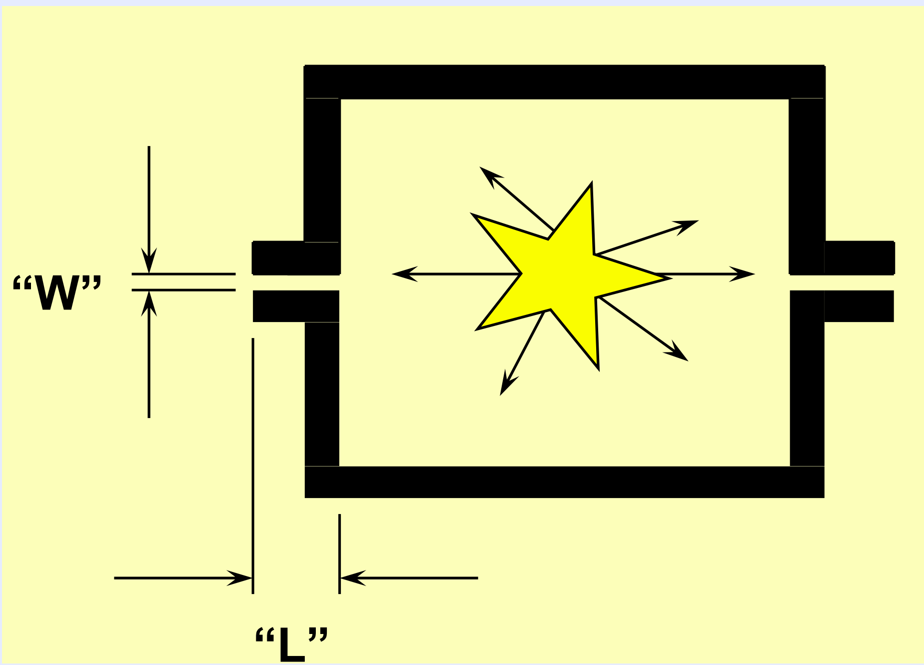
Flameproof Enclosure “d”



- Enclosure min. IP 54
- Enclosure must withstand resulting explosion pressure without any deformation - Pressure-piling
- Transmission of the flame prevented by the toleranced flamepaths
- Gas group IIA, IIB or IIC depending on the MESG
- Temperature class dependent on max. surface temperature due to the heat loss of all components T1-T6

Type of protection "Increased Safety" Exe

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Increased safety "e" is the type of protection by which measures are applied so as to prevent with a major degree of security the possibility of excessive temperatures and of the occurrence of arcs and sparks in the interior and on the external parts of electrical apparatus which does not produce them in normal service.

The main types of apparatus in the type of protection increased safety are :

- Terminals
- Measuring instruments - moving iron
- Transformers
- Squirrel cage motors

Apparatus such as squirrel cage motors and transformers also need additional thermal protection to ensure that the temperature rise, in normal and in the case of any fault, does not exceed that of the limiting temperature.

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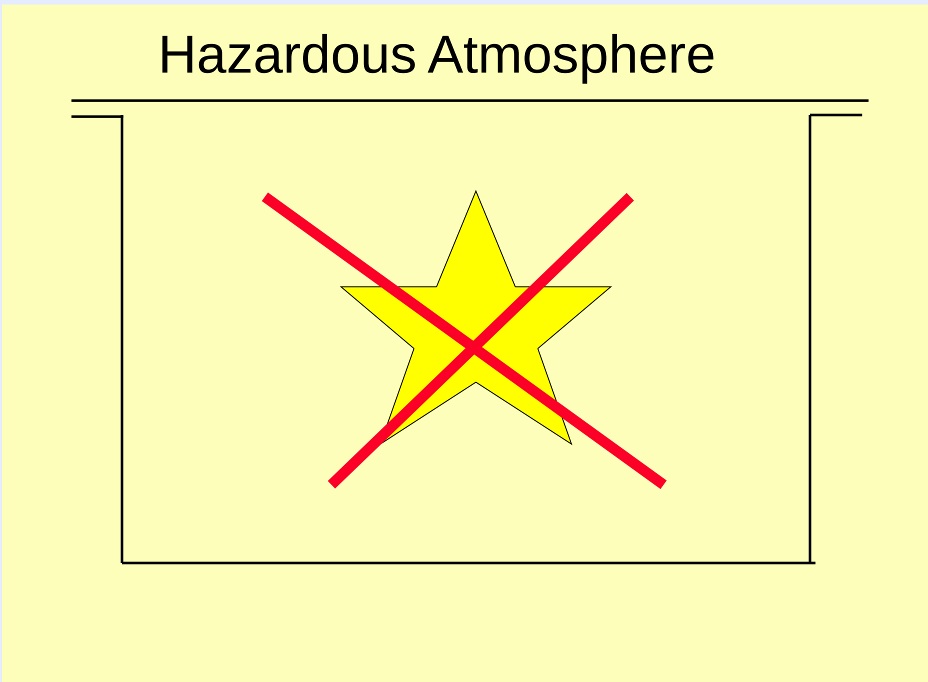
Increased safety “e”



- No arks or sparks in normal operation
- No hot spots above the temperature classification
- Creepage and clearance distances enlarged in comparison to normal installation
- Special choice of insulating materials
- Special terminals in regard to contact pressure and self-loosening

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Increased safety "e"

Special requirements for Exe enclosures and parts

- Enclosure min. IP 54
- Limiting temperature is the highest permissible temperature of an electrical apparatus or a part of an electrical apparatus.
- Impact resistant - min. 7Nm for enclosures, 4Nm for windows, etc.
- No electrostatic charges due to design or low surface resistance - > 10^9 Ohm
- Flame retardance to UL94 V0
- Resistant to climatic stresses, UV, weather etc.
- Shock test for glass windows etc.
- Resistant to chemicals

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Type of protection
“Oil Immersion” Exo

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Oil immersion "o" is a type of protection in which the electrical apparatus or parts of the electrical apparatus are immersed in oil in such a way that an explosive atmosphere which may be above the oil or outside the enclosure cannot be ignited.

Main types of apparatus in oil immersion are :

- Switching units
- Circuit breakers
- Transformers

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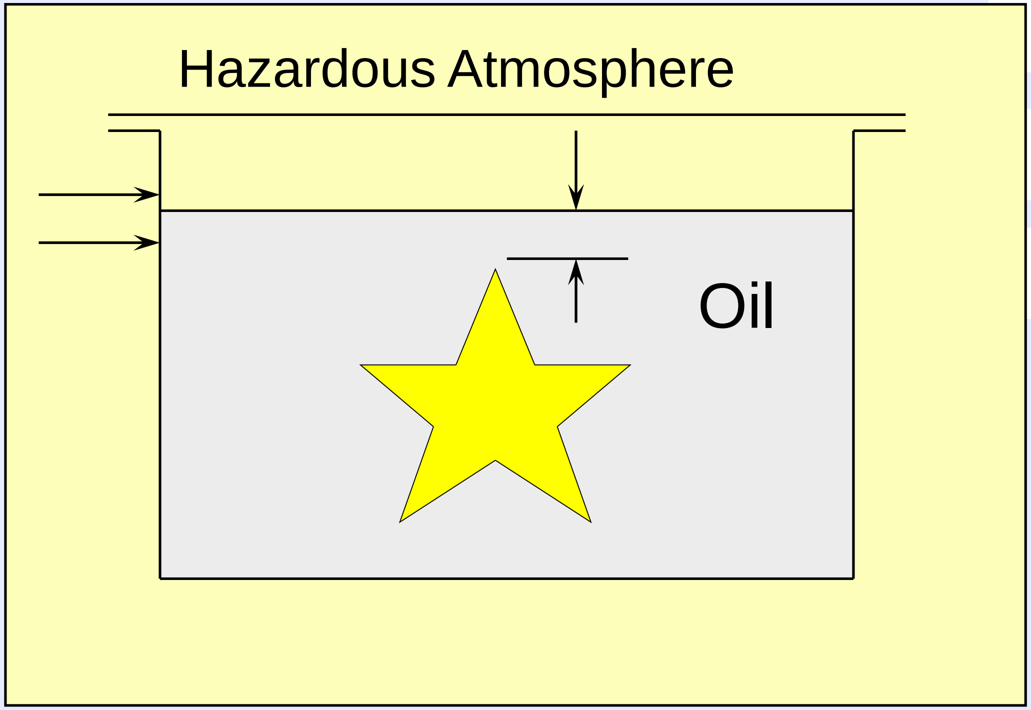
Oil immersion “o”



- Mineral oil to IEC 296
- All parts capable of producing arks or sparks in normal operation to be covered by a depth of min. 25mm
- Highest and lowest level to be clearly marked
- Oil level easily checked while in service
- Max. oil temperature 115 ºC for class I or 105 ºC for class II

Type of protection “Powder Filling” Exq

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Powder filling "q" is a type of protection in which the enclosure of the electrical apparatus is filled with a material in a finely granulated state so that, in the intended conditions of service, any arc occurring within the enclosure of the electrical apparatus will not ignite the surrounding atmosphere. No ignition shall be caused either by flame or by excessive temperature of the surfaces of the enclosure.

Main types of apparatus in powder filling are :

- Fuses
- Capacitors
- Electronic circuit boards - EVG

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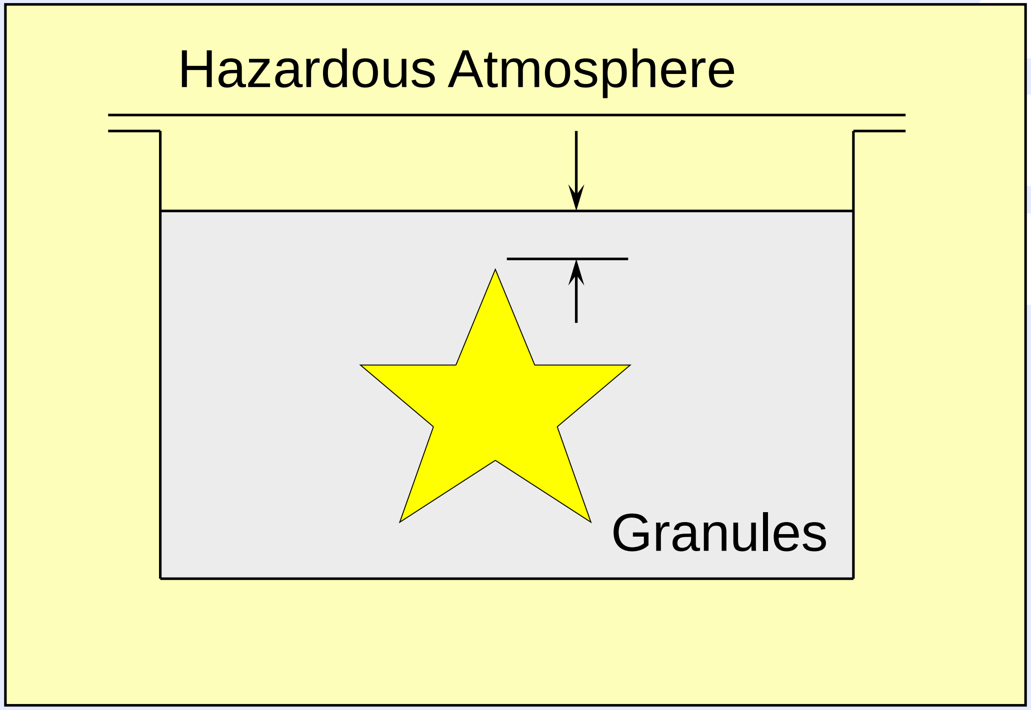
Powder filling “q”



- Enclosure min. IP 54
- Hydraulic pressure test for enclosure - 0.5 bar for 1 minute - max deformation 0.5mm for any dimension
- Granule size max. 1.6mm
  min. 250µm
- Granule shall not contain more that 0.1% by weight of water
- Minimum distance between bare live parts and enclosure wall 4mm

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Type of protection “Pressurization” Exp

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Pressurized apparatus "p" is a type of protection by which the entry of a surrounding atmosphere into the enclosure of the electrical apparatus is prevented by maintaining, inside the said enclosure, a protective gas at a higher pressure than that of the surrounding atmosphere.
The over pressure is maintained with or without continuous flow of the protective gas.
The protective gas can be either air, inert gas or an other suitable gas.

Main types of apparatus in pressurized enclosure are :

- Switch rooms
- Apparatus too large or difficult to use another type of protection.

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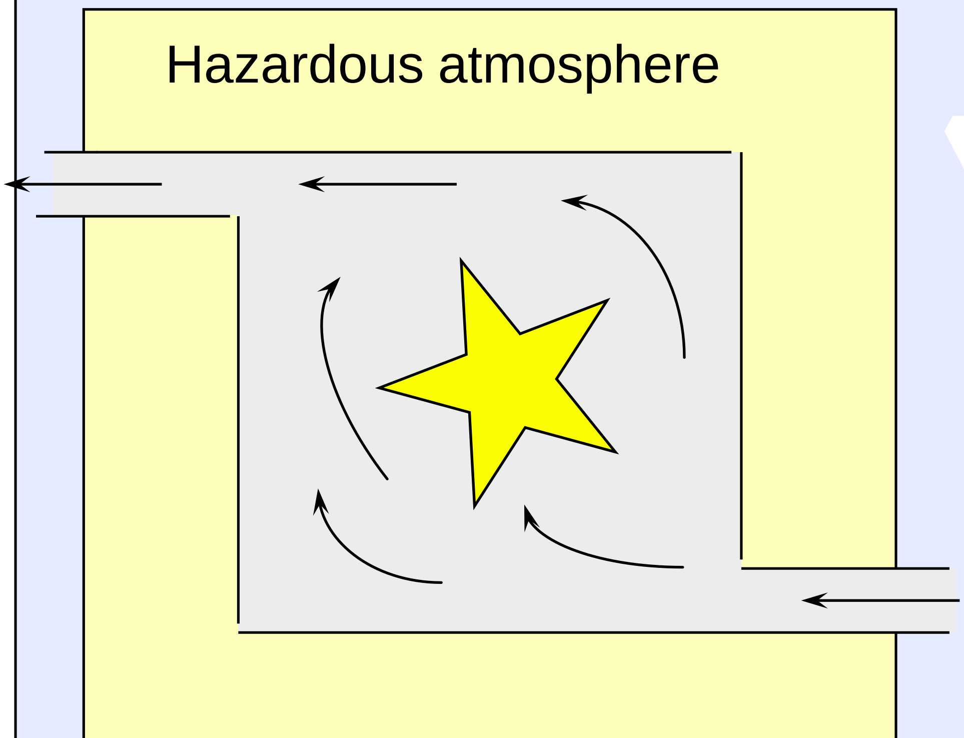
Pressurized Enclosure “p”



- Over pressure must be continuously checked - minimum pressure relative to external pressure 0.5mbar
- Automatic devices to disconnect electrical supply if over pressure fails
- Doors or covers must be interlocked
- Energization not possible till apparatus has been purged sufficiently to reduce concentration of any flammable gas or vapor. Minimum 5 times the volume of free space and ducts.

Type of protection "Encapsulation" Exm

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Encapsulation "m" is a type of protection in which the parts that could ignite an explosive atmosphere are enclosed in a resin sufficiently resistant to environmental influences in such a way that this explosive atmosphere cannot be ignited either by sparking or heating which may occur within the encapsulation.

Main types of apparatus in encapsulation are :

Electronic circuit boards - EVG
Miniature motors

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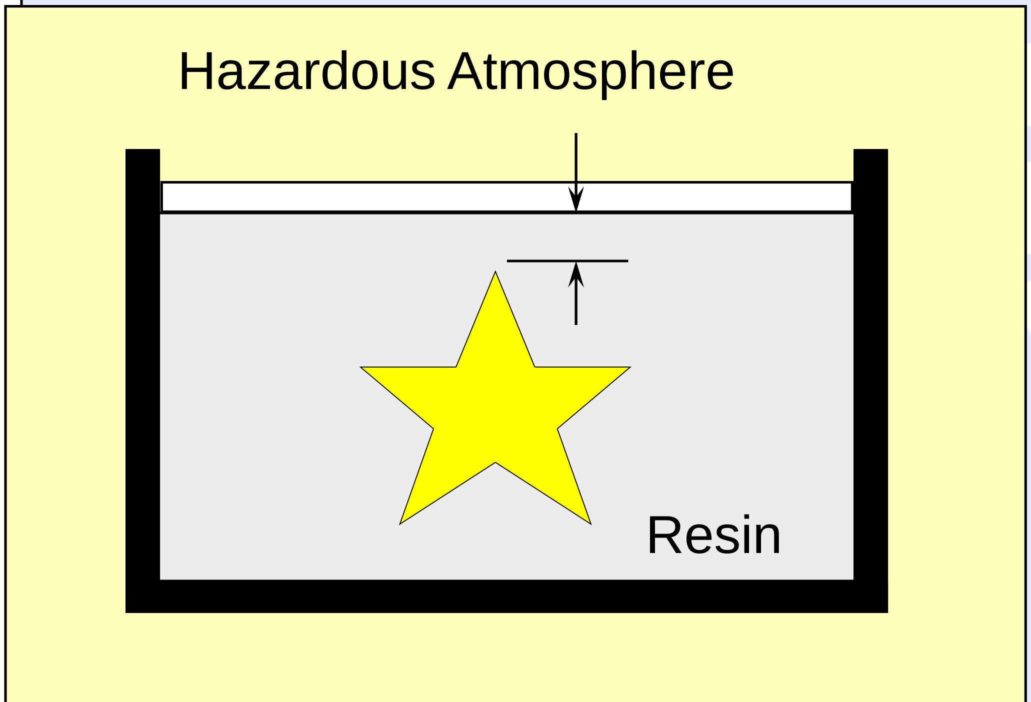
Encapsulation “m”



- Resin such as thermo-setting, thermoplastic and elastomer materials with and without fillers and/or other additives
- Temperature range of the resin is the temperature range within which the characteristics of the resin satisfy the standard not only in service but also in store.
- Continuous service temperature of the resin is the maximum temperature to which the resin can be continuously exposed, according to the information from the manufacturer.

Type of protection
"Intrinsic Safety" Exi

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Intrinsic Safety "i"

An intrinsically safe circuit is a circuit in which no spark or any thermal effect produced in the test conditions prescribed in this standard (which include normal operation and specified fault conditions) is capable of causing ignition of a given explosive atmosphere.

Intrinsically safe electrical system comprises an assembly of inter-connected items of electrical apparatus, described in a descriptive system document in which the circuits or parts of circuit intended to be used in a potentially explosive atmosphere are intrinsically safe circuits.

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Intrinsic Safety “i”

Intrinsically safe electrical apparatus is electrical apparatus in which all the circuits are intrinsically safe.

Associated electrical apparatus is electrical apparatus in which the circuits are not all intrinsically safe but which contains circuits that can affect the safety of intrinsically safe circuits connected.
Example : a recorder which is mounted not in a potentially explosive atmosphere, but which is connected to a thermocouple situated within a potentially explosive atmosphere where only the recorder input circuit is intrinsically safe.

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Intrinsic Safety “i”

Intrinsically safe electrical apparatus is arranged in Groups and Classes according to General requirements of DIN EN50 014 / VDE 0170/0171 part 1. ie. Group IIA, IIB and IIC.

The selection into Groups using the MIC method.

Intrinsically safe electrical apparatus is additionally divided into categories : “ia” and “ib”

The European Standards worked out the requirements for both categories “ia” and “ib” of the electrical apparatus under the presupposition that electrical apparatus of category “ia” is suitable for Zone 0 and that of category “ib” for use in Zone 1.

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Intrinsic safety “i”

- Category “ia” - comprises electrical apparatus that shall not be capable of causing ignition in normal operation, with a single fault and with any combination of two faults applied, with the following factors :
  - 1.5 x in normal operation and with one fault
  - 1.0 x with 2 faults

- Category “ib” - comprises electrical apparatus that shall not be capable of causing ignition in normal operation, with a single fault with the following factors :
  - 1.5 x in normal operation and with one fault
  - 1.0 x with 1 fault, if the electrical apparatus contains no switch contacts in parts likely to be exposed to a potentially explosive atmosphere and the fault is self-revealing

Selection of Electrical Apparatus

Suitability for installation

- Certification and marking.
- Suitability for environment

Selection of Electrical Apparatus

Types of entry

- Conduit installation.
- Cable installation by Cable Glands
  - i) Fixed cables
    - a) Direct entry in to Exd
    - b) Entry in to Exe
  - ii) Flexible cables

Selection of Electrical Apparatus

Other factors for the selection

- Advantages of Ex de combinations
  Individual component and individual contact encapsulation.
- Ease of installation
- Ease of operation
- Ease of maintenance