MIE TALK - Augustus 2015

SELECTION OF EXPLOSION PROTECTED EQUIPMENT

EXPLOSIVE ATMOSPHERES

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Abstract

How can we mitigate the risks of explosions and fire in the Ex industry? Are people declared competent to understand the selection and installation of explosion protected equipment in hazardous locations? Many people have been killed or injured due to human error or incorrect selection of Ex equipment. Explosion Protected Equipment in hazardous locations is not always installed, maintained and inspected as required by legislation and the applicable standards. This can be a risk to workers and plants. This paper explains all about hazardous locations and the selection of equipment for such locations, as well as the applicable standards and regulations.

Introduction

Recent explosion-related industrial accidents throughout the world have caused extraordinary environmental damage and cost many lives. While national regulations exist in some countries, there is an urgent need for an international approach to increase safety wherever workers and communities are exposed to high risk of explosions occurring. All workers working in hazardous locations must be declared competent to express an opinion as per Electrical Machinery Regulation (EMR). Human Error or incompetency has been found to be at least one part of the domino in a major disaster.

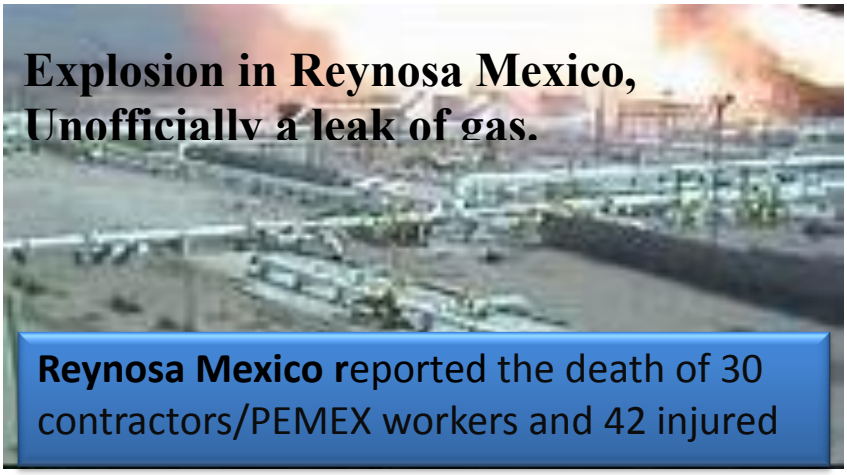

Figure 1: Results of methane explosion (Reynosa Mexico)

Selection of Explosion Protected Equipment (EPE) for hazardous locations

All hazardous locations must comply with the OHS Act as well as the relevant code of practices and standards. The Electrical Machinery Regulation (EMR) Section 9 requires that all hazardous areas must be classified and equipment used in such areas must be certified. All EPE local manufactured and imported must be certified by a local Approved Test Laboratory (ATL) as required by regulation ARP 0108. All workers working in hazardous locations must receive proper Ex training and be declared competent to express an opinion as per EMR 9(8).

Fire triangle

Before a fire or explosion can occur, three conditions must be met simultaneously. A fuel (ie. combustible gas) and oxygen (air) must exist in certain proportions, along with an ignition source (heat), such as a spark or flame. The ratio of fuel and oxygen that is required varies with each combustible gas or vapor.

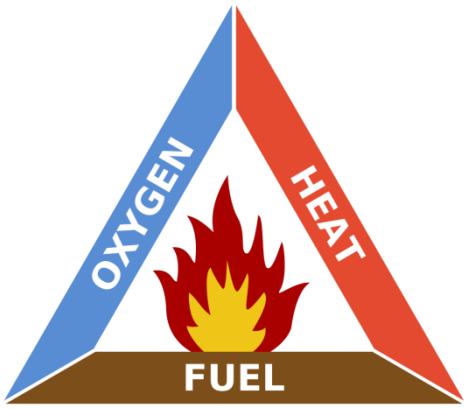

Figure 2: Fire triangle

Successfully suppressing or separating one or more of these three components can avoid a fire or explosion

EMR 9(1) Area Classification of hazardous areas

STEP 1

Establish if it is a hazardous area due to the presence of an explosive gas or an explosive dust and divides the area into different zones.

What is a hazardous area?

A hazardous area is an area in which an explosive gas atmosphere or combustible dust, in the form of a cloud is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

Petrochemical plants as well as combustible dust areas are then divided into areas of risk of release of gas, vapor or dust known as **zones**. The process of determining the type and size of these hazardous areas is called area classification. The guidance on assessing the extent of the hazard is given in the current edition of IEC/SANS 60079-10-1 for gas zones. The gas zones consist of zones 0; 1 and 2. The applicable standard for dust zones is IEC/SANS 60079-10-2. The dust zones consist of zones 20; 21 and 22.

Area Classification takes into account **gas groups** and **temperature classes**.

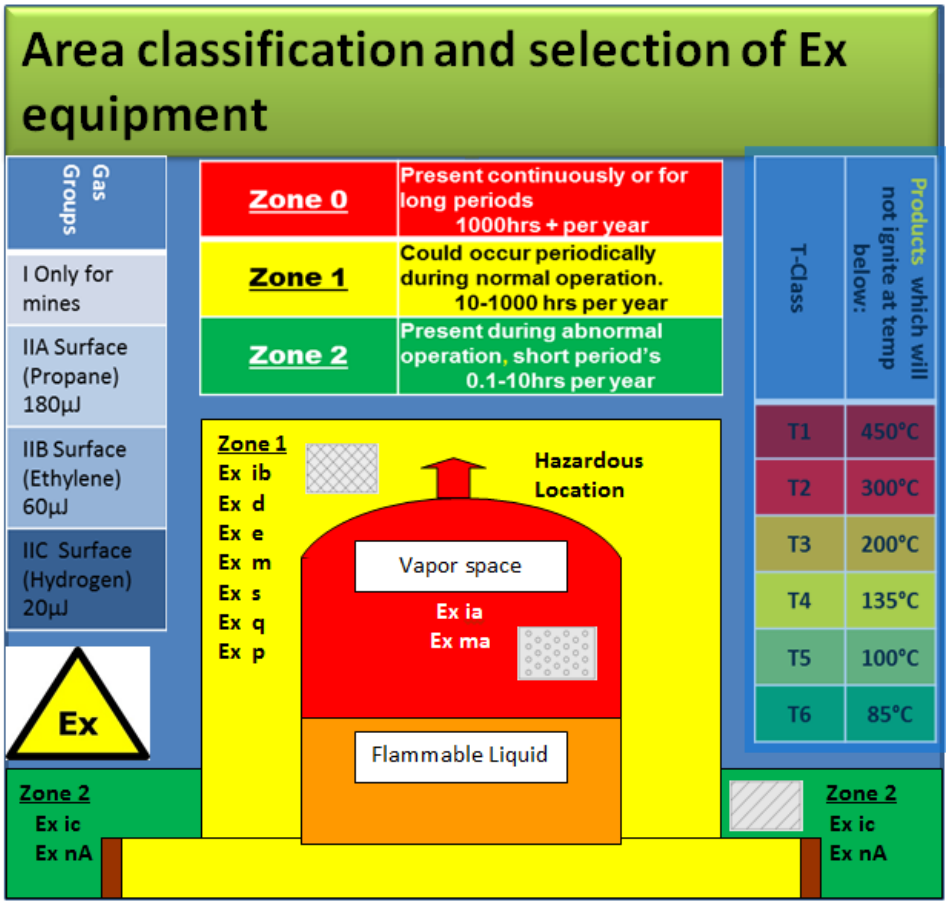

Figure 3: Typical zone classification

NOTE: Zone 0 is the **most severe zone** and requires the highest level of protection – **EPL Ga**

EPL: Equipment protection level

An explosion occurs when an ignition source is in contact with the explosive atmosphere. This situation must be absolutely avoided. In the **very high** risk areas like zone 0 and zone 20 (see table 1), in which the risk of explosion is caused by the presence of explosive gas or dust for long periods of time during the year, the equipment installed must have very high levels of protection. In **low** risk areas, as the Zone 2 for gas and the Zone 22 for dust (see table 1), you can use equipment with lower levels of protection. The risk analysis can be done by means of a risk assessment as per SANS 60079-10-1 and SANS 60079-10-2.

Group	Ex risk	Risk	Zone	EPL	Minimum type of protection
I (mines)	energized	Very high	0	Ma	Same as Ga
I (mines)	de-energized in presence of Ex atmosphere	High	1	Mb	Same as Gb
II (gas)	explosive atmosphere > 1000 hrs/yr	Very high	0	Ga	ia, ma
II (gas)	explosive atmosphere between 10 and 1000 hrs/yr	High	1	Gb	ib, mb, px, py, e, o, q, d
II (gas)	explosive atmosphere between 1 and 10 hrs/yr	Low	2	Gc	nA(ec), ic, pz,
III (dust)	explosive surface > 1000 hrs/yr	Very high	20	Da	ta; ia; ma
III (dust)	explosive surface between 10 and 1000 hrs/yr	High	21	Db	tb, ib, mb, p
III (dust)	explosive surface between 10 and 10 hrs/yr	Low	22	Dc	tc, ic, p

Table 1: EPL's and Zones

STEP 2

Gas Groups

Established which gas or dusts are present and is it underground (Group 1) or surface (Group II)?

Hazardous areas are defined by three main principles:

- The **type** of hazard - gas, vapour, dust
- The likelihood of the hazard being present in flammable concentrations - determine the lower explosion limits (LEL) and upper explosion limits of the flammable substance (UEL). The mixture between the LEL and UEL is explosive and is called the explosion range.
- LEL - the lowest concentration of given vapour in air below which ignition will not take place.
- UEL - the highest concentration of given vapour in air above which ignition will not take place.

It is important to note that each gas has its own LEL and UEL, as shown in the table below.

The (auto) **ignition temperature** of the hazardous material – The temperature classification of the

equipment must not exceed the ignition temperature of the flammable gas or vapour.

Properties of certain flammable industrial gases and vapours					
Gas (substance)	**Ignition temperature**	**Explosive limit in air** % (volume fraction)		**Typical flash point**	**Relative density**
	°C	**Upper**	**Lower**	**°C**	**(air = 1)**
Group I					
Methane	537	15,0	5,0	−188	0,55
Methane and coal dust	150	15,0	5,0	–	0,55
Flammable gasa (methane and other hydrocarbon mixtures)	–	22,0b	4,5b	–	–
Subgroup IIA					
Blast-furnace gas	–	70,0	28,0	–	–
Propane	465	9,5	2,0	< −6,7	1,5
Petrol	560	8,0	1,2	−45	2,8
Diesel	257	7,5	0,6	> 55	> 1
Illuminating paraffin or kerosene	210	8,9	1,4	95	> 1
Power kerosene	–	< 5,0	> 0,7	> 38	> 1
Butane	430	8,5	1,5	< −6,7	2,0
Pentane	309	7,5	1,5	< −51,0	2,5
Hexane	260	7,0	1,0	< −29,0	3,0
Heptane	233	6,0	1,0	−1,1	3,5
iso-Octane	530	3,5	0,5	−12,2	3,9
Decane	250	–	0,5	46,0	4,9
Benzene	538	8,0	2,0	−11,1	2,7
Xylene	482	6,0	1,0	25,0	–
Cyclohexane	285	8,5	1,0	0	2,9
Acetone	538	13,0	3,0	−9,4	2,0
Ethyl-methyl ketone	515	12,0	2,0	1,7	2,5
Methyl acetate	454	15,5	3,0	−10,0	2,5
Ethyl acetate	427	11,5	2,0	7,2	3,0
n-Propyl acetate	450	8,0	1,5	4,5	3,5
n-Butyl acetate	421	–	1,5	40,5	4,0
Amyl acetate	398	–	1,0	34,4	4,5
Chloroethylene	413	16,0	6,2	13,3	3,4
Methanol	464	36,5	5,5	18,3	1,1
Ethanol	423	19,0	2,5	18,3	1,6
Butanol	–	–	–	23,9	2,6
iso-Butanol	427	–	1,5	27,8	2,6
n-Butanol	343	–	1,5	28,9	2,6
Amyl alcohol	371	–	1,0	52,8	3,0
Ethyl nitrite	90	50,0	3,0	−35,0	2,6
Ammonia	651	27,0	15,0	–	0,59

Subgroup IIB					
Ethylene	450	35,0	2,5	< −6,7	0,97
Diethyl-ether	180	48,0	1,5	−40,0	2,6
Ethylene oxide	429	80,0	3,0	< −17,8	1,5
Carbon monoxidec	651	75,0	12,0	–	0,96
Buta-1:3-diene	450	12,0	2,0	–	1,9
Coal gas (town gas)	649	31,0	5,5	–	–
Coke-oven gas	–	34,0	4,4	–	–
Subgroup IIC					
Acetylene	337	82,0	2,5	–	0,90
Carbon disulfide	100	50,0	1,0	−30,0	2,6
Hydrogen	585	75,0	4,0	–	0,07
Water gas	–	70,0	6,0	–	–
Ethyl nitrate	–	–	3,0	10,0	3,1

Table 2: Flammable Properties

Gas Groups

Electrical equipment used in gas atmospheres is divided into two groups:

Group I - Equipment used in mines with atmospheres containing methane or gases and vapours of equivalent hazard.
Group II - All other equipment; which is further subdivided into three subgroups.
Group IIA - Atmospheres containing propane, or gases and vapours of equivalent hazard.
Group IIB - Atmospheres containing ethylene, or gases and vapours of equivalent hazard.
Group IIC - Atmospheres containing hydrogen, or gases and vapours of equivalent hazard.

Industry	Gas Group	Substance	MIE	Selection of equipment
Mining Industry Group I	I	Methane	200µJ	Equipment only suitable for mines unless it is additional approved for surface: Marked I/IIC
Surface Industry Group II	IIA	Propane	180 µJ and higher	II; IIA; IIB and IIC certified equipment may be used in an IIA area.
	IIB	Ethylene	60 µJ -180 µJ	II; IIB and IIC certified equipment may be used in an IIB area.
	IIC	Hydrogen	20 µJ – 60 µJ	Only II & IIC certified equipment is allowed to be used in an IIC area.

Table 3: Gas groups

Group IIC is the most severe group. Hazards in this group can be ignited very easily indeed.

Dusts and Fibres (Group III)

Group III is subdivided into three sub groups:

Dusts and Fibres (Group III) Surface	IIIA	Combustible flying's
	IIIB	Non-conductive dust
	IIIC	Conductive dust

Table 4: Dust groups

STEP 3

Temperature classification

Group II (Gas)

Temperature class of the selected equipment may not exceed the ignition temperature of any gas or explosive atmosphere present. Knowing the ignition temperature of the explosive atmosphere, we are better able to decide upon the appropriate type of electrical apparatus required.
The maximum surface temperature of electrical or mechanical apparatus must always be lower than the ignition temperature of the surrounding explosive atmosphere. Temperature class is not the operating temperature range of the equipment, but the maximum permissible surface temperature of the equipment, in relation to + 40°C ambient temperature.

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

Table 5: Temperature classification

All flammable gases and vapours are placed in a gas group and a temperature class as per table 6 below.

Groups		Gas	Ignition temperature (°C)	Temperature class					
				T1	T2	T3	T4	T5	T6
I		Methane	537	#					
II	A	Propane	465	#					
		Benzene	538	#					
		Ethyl nitrite	90						#
II	B	Ethylene	450	#					
		Diethyl-ether	180				#		
		Coal gas (town gas)	649	#					
II	C	Acetylene	337		#				
		Hydrogen	560	#					
		Carbon disulfide	100						#

Table 6 : Combustible Gas Ignition temperatures

Group III (Dust)

Dusts and fibres are also defined in terms of their ignition properties including dust cloud ignition properties. The user must take both the cloud and layer temperatures into consideration during selection of Ex equipment.

NOTE: Selection will always follow the area classification

After assessment of the installation, the user should consider the following criteria when selecting electrical equipment:

- Maximum permissible surface temperature of the equipment, taking into consideration the type of dust,
- the ignition temperature of the dust cloud and,
- if dust deposits cannot be excluded, the ignition temperature of the dust layer.

Ignition Temperature		
Material	Cloud	Layer
Coal Dust	380˚C	225˚C
Polythene	420˚C	(melts)
Methyl Cellulose	420˚C	320˚C
Starch	460˚C	435˚C
Flour	490˚C	340˚C
Sugar	490˚C	460˚C
Grain Dust	510˚C	300˚C
Phenolic Resin	530˚C	> 450˚C
Aluminium	590˚C	> 450˚C
PVC	700˚C	> 450˚C
Soot	810˚C	570˚C

Table 7: Ignition temperatures for common flammable dusts and fibers

STEP 4

EMR9(2) Selection of Explosion Protected Equipment (EPE)

Selection of EPE will always follow the area classification. The type of explosion protection of the equipment is to be suitable for the zone of use. All Explosion Protected Equipment must be covered by an approved Inspection Authority (IA) certificate issued by an accredited Approved Test Laboratory (ATL) to comply with the applicable standards. The selection of suitable apparatus plays an important role when setting up a plant in hazardous areas. A greater effort must be made to avoid hot surfaces or prevent equipment from generating ignitable sparks.

Typical example and interpretation of an Ex marking:

Ex d I/IIC T3 Gb

- **Ex** – Explosion-proof electrical equipment
- **d** – Type of protection is ‘Flameproof enclosure
- **I** – Gas Group I – Only for mines
- **II** – Gas Group II - Surface industries
- **C** – Gas sub group = C
- **T3** – Temperature class T3 (300 degrees centigrade surface temperature)
- **Gb** – Equipment protection level (EPL)

Methods of Explosion Protection			
Type of Protection	**EPL**	**Zones**	**Method**
Ex d Flameproof Enclosure	**Gb**	**1 & 2**	**Designed to prevent any ignition from spreading**
Ex q Powder Filling	**Gb**	**1 & 2**	
Ex i Intrinsic Safety Ex ia;	**Ga**	**0; 1 & 2**	**Designed to limit the ignition energy of the circuit**
Ex ib;	**Gb**	**1 & 2**	
Ex ic	**Gc**	**Only 2**	
Ex e Increased Safety	**Gb**	**1 & 2**	**Designed to prevent any ignition from arising**
Ex N or Ex nA Non Sparking	**Gc**	**Only 2**	
Ex m Encapsulation	**Gb**	**1 & 2**	**Designed to prevent the flammable mixture reaching a means of ignition**
Ex p Pressurisation	**Gb**	**1 & 2**	
Ex o Oil immersion	**Gb**	**1 & 2**	
Ex nA Non-sparking or Ex nR Restricted Breathing	**Gc**	**Only 2**	

Table 8: Protection Techniques and Methods

STEP 5

Ingress protection (IP) Ratings

Ingress protection of the equipment shall be suitable for prevailing conditions at the point of use. The IP rating of Ex equipment is of outmost importance as we do not want any foreign objects or a flammable substance to penetrate the Ex enclosure. IP rating is the resistance offered by the fixture to the penetration of solids and liquids is indicated by the IP (Ingress Protection) rating:

- This is a two digit number:
- The first number identifies the degree of protection against the ingress of solids;
- The second number against liquids
- e.g. IP65 indicates total protection against dust and protection against low pressure jets of water.

First number	Object size protected against	Effective against
0	Not protected	No protection against contact and ingress of objects
1	>50mm	Any large surface of the body, such as the back of the hand, but no protection against deliberate contact with a body part.
2	>12.5mm	Fingers or similar objects.
3	>2.5mm	Tools, thick wires, etc.
4	>1mm	Most wires, screws, etc.
5	Dust Protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact.
6	Dust Tight	No ingress of dust; complete protection against contact.

Second number	Object size protected against	Effective against
0	Not protected	-
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	Splashing water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	Water jets	Water projected by a nozzle (6.3mm) against enclosure from any direction shall have no harmful effects.
6	Powerful water jets	Water projected in powerful jets (12.5mm nozzle) against the enclosure from any direction shall have no harmful effects.
7	Immersion up to 1m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
8	Immersion beyond 1m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.
9	High pressure and temperature water jet	Water projected at high pressure and high temperature against the enclosure from any direction shall not have harmful effects.

Table 9: IP Rating

STEP 6

Ambient temperature rating

Ambient temperature rating of the equipment must cover full range of possible temperatures in the area of use:

- If the marking (or the certificate) of the equipment does not include an ambient temperature range, this equipment shall be used only within the ambient range from –20°C to +40°C.

Conclusion

People are our most valuable asset and the industry must ensure a safe work environment as per Section 8 and Electrical Machinery regulation 9 as per the latest issue of the Occupational Health and Safety Act and Regulations (85 0f 1993).

Reference

[1] SANS 60529; SANS 60079-10-1; SANS 60079-10-2; SANS 60079-14; SANS 60079 – 17; SANS 10108; ARP 0108

Applicable Standards

IEC/SANS 60079 Part 0: Equipment - general requirements
SANS 60079 Part 10: Classification of hazardous areas

SANS 60079 Part 14: Installation (and selection) of equipment in hazardous areas.
SANS 60079 Part 17: Inspection and maintenance of equipment
ARP 0108: Regulatory requirements for explosion-protected apparatus
SANS 10108: The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142-1: The wiring of premises