WHITE PAPER

WHAT IS POTENTIALLY EXPLOSIVE ATMOSPHERE CERTIFICATION AND WHY YOU MAY NEED IT!

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What is potentially explosive atmosphere certification and why you may need it!

The Explosive Atmospheres Directive (ATEX 137) is a European Union Directive which requires employers to protect workers from the risk of explosive atmospheres.

The ATEX Directive was ratified and its implementation mandatory from the 1st of July 2003 and was subject to various stages of implementation during the following three years and finally came into force for all workplaces on 30 June 2006.

Despite the fact that the ATEX Directive has been in force for many years it is evident that there are many organisations that do not fully understand the Directive requirements!

ATEX is the name commonly given to the framework for controlling explosive atmospheres and the standards of equipment and protective systems used in them. It is based on the requirements of two European Directives.

1. Directive 99/92/EC (also known as 'ATEX 137' or the 'ATEX Workplace Directive') on minimum requirements for improving the health and safety protection of workers potentially at risk from explosive atmospheres.

2. Directive 94/9/EC (also known as 'ATEX 95' or 'the ATEX Equipment Directive') on the approximation of the laws of Members States concerning equipment and protective systems intended for use in potentially explosive atmospheres.

In summary, many manufacturing and processing industries generate potentially dangerous substances which are any substances used or present at work that could, if not properly controlled, cause harm to people as a result of a fire or explosion. They can be found in nearly all workplaces and include such things as solvents, paints, varnishes, flammable gases, such as liquid petroleum gas (LPG), dusts from machining and sanding operations and dusts from foodstuffs.

Previously there has been no mandatory obligation to use certified equipment (or indeed to classify an area as potentially explosive, however in the event of an accident companies were liable to prosecution), European Directive 137 (The protection of workers from potentially explosive atmospheres) makes it mandatory under European law to assess for an explosion risk and classify the area accordingly.

Once an area is classified as potentially explosive, a risk analysis will normally dictate that only electrical and mechanical equipment that is suitably certified can be installed. Directive 137 has increased the amount of 'Classified or Zoned' areas, and hence increased the demand for certified equipment. The ATEX Directive (94/9/EC) has forced manufacturers to gain certification of electrical and/or mechanical products that are intended for use in a potentially explosive atmosphere. Products without the appropriate certification are not legally allowed to be placed or offered on the European market after July 1st 2003.

As a result of the combination of these two Directives many manufacturers and workplaces have been forced to deal with issues with which they are unfamiliar, some organisations still operating in ignorance of the law or who have been operating essentially illegally are now addressing their obligations all be it late in the day. The following article deals with the basic codes, concepts and methodology of explosion protection.

What is an explosion?

An explosion is any uncontrolled combustion wave. In order to create an explosion there has to be fuel (for example an explosive gas such as hydrogen), and an oxidizer (such as the oxygen in air) and a source of ignition energy (for example, a hot surface or an electrical spark). These three items are commonly referred to as 'the fire triangle' and are represented as below.

Figure 1. Fire Triangle

In addition to this, two additional facets are required; something to mix the fuel and the oxidizer (such as the turbulence created in a gas leak under pressure) and containment. It is however common industrial practice to use the term ‘explosion’ for both confined and unconfined combustion.

For any mixture of a combustible gas or vapour with an oxidizer there is critical ignition energy. If one releases less than that critical amount of energy into the mixture, there will not be a self propagating explosion. Some combustion may occur transiently, but the combustion wave will not grow and become self propagating. If one releases at least the critical amount of energy, the combustion wave will pass through the incipient stages of growth and become self propagating as a plane wave, resulting in an explosion.

At a critical concentration called the most easily ignited concentration (MEIC), the amount of energy required to cause ignition is minimal. If the ignition experiment is conducted under conditions where it is assumed that all the energy injected into the gas/ vapour cloud is used in the combustion process, the critical energy at the MEIC is called minimum ignition energy (MIE). As the concentration is varied from the most easily ignited concentration the amount of energy required to cause ignition increases, until at certain points, the mixture is no longer explosive. These points (derived by experiment) are referred to as the lower explosive limit (or LEL) at the lower concentration limit, and the upper explosive limit (or UEL) at the higher concentration limit.

The LEL and UEL are not inherent properties of a combustible mixture. Their values depend on the nature of the experiment by which they are determined, especially the size of the vessel and the energy available from the ignition source. No prudent person controlling concentration to reduce the risk of an explosion would operate much higher than 50% of the LEL except under very carefully controlled conditions. In most situations the limit is set at 25% or lower.

Effects of Oxygen Enhancement, Temperature, and Pressure

Oxygen enrichment increases the heat release within the combustion zone of the developing wave front and therefore decreases the required initial energy contribution from the ignition source. The most easily ignited concentration of oxygen and vapours or gases ignites at about one hundredth the minimum ignition energy of the most easily ignited concentration of the same vapour or gas in air. Because the flame velocities are considerably higher, the pressure rise in an explosion proof enclosure may also be much higher. No means of explosion protection considered safe for atmospheric mixtures should be considered safe in oxygen enriched mixtures without careful examination.

The qualitative effect of increasing temperature is relatively easy to estimate. Every material has a spontaneous ignition tempera-ture, SIT (or AIT, autogenous ignition temperature may occur without a spark or flame. If the product is heated well above its flash point, a temperature is reached at which the product will ignite spontaneously, without any external source of ignition, provided sufficient oxygen is present. This is called autogenous ignition and the temperature at which it occurs is the auto-ignition temperature of the product) at which it will ignite spontaneously. Obviously, if the temperature of a mixture is raised, the amount of electrical energy required will decrease, reaching zero at the AIT.

The effect of pressure is understandable if one considers that when pressure increases the number of molecules per unit volume increases. The heat release per unit volume will consequently increase, and the ignition energy required causing the incipient flame sphere to grow to its critical diameter decreases. Similarly, decreasing pressure decreases the amount of energy released in the combustion zone and increases the required electrical ignition energy. This relationship has been verified experimentally over many atmospheres of pressure change. Doubling the pressure of a gas decreases the ignition energy to approximately 25% of its former value.

Historical Background of explosion protection

The first hazardous area was discovered in the early coal mines. This area held a double hazard: methane gas (firedamp) and coal dust. Methane gas is absorbed into the pores of coal. When the coal is mined the methane exudes, a process that takes a relatively short time. To be completely free of methane, coal has to be stored for a period of up to 1000 hours.

When miners worked an 8 hour shift pattern, the mined coal would be left in the shaft until the next day, during which time the methane would start to exude into the air in the shaft. The methane would collect in pockets at the roof of the mine and form an explosive layer. The miners returning for the next shift would carry with them the means of igniting the gas, hat mounted candles, and hand carried oil lanterns. The resulting ignition of the methane would in itself not necessarily be fatal for the miners. It was the secondary ignition of coal dust, thrown up into a cloud by the methane explosion, that resulted in a more violent and deadly detonation.

The first method used to remove the methane hazard was for a person to crawl along the mine floor holding a lighted lantern in their outstretched hand. This procedure would 'safely!' ignite the methane layer and burn it off before the miners started work. The person performing this task was known as the 'fireman' and it soon became apparent that there were very few volunteers for this hazardous job. This human form of Gas Detection resulted in prisoners being offered short jail terms if they would volunteer for the position.

With the advent of forced ventilation in the mines, the hazards were reduced by the dilution of the methane with fresh air so that it was below its explosive limit. When electrical equipment was first introduced into the mines, there were some explosions due to electrical sparking. However, it was discovered that totally enclosed motors were able to contain explosions without transmitting them into the surrounding external atmosphere. This concept was transferred to the design of other electrical equipment; locating it inside substantial cast iron enclosures with tight fitting joints.

Later, low voltage signalling bells were introduced into the mines. It was believed that, since these bells operated on a very low voltage (12V or less), they would be safe. However, in the years 1912 and 1913, there were two disastrous mine explosions in England, which were traced to the signalling bells. Research showed (Mines Research Establishment, Buxton, England) that these low voltage circuits were capable of igniting mine gases, it also lead to new circuit designs in which the stored energy was reduced to a non ignition capable level. This technique was labelled 'intrinsic safety' and it was the beginning of a new era in safety methods for explosive hazardous areas.

Definitions and Codes

An area of plant is defined as a hazardous area if it contains flammable gases, vapours, combustible dusts and easily ignitable fibres and flyings which may be expected to be present in concentrations such as to require special precaution for the construction and use of electrical equipment in their presence. An explosive atmosphere consists of a mixture of flammable substances in air in such proportions that it can be exploded by excessive TEMPERATURES, ARCS OR SPARKS. The gases, vapours or mists will only explode when mixed with air between specific percentage mixtures, these are called:

LOWER EXPLOSIVE LIMIT (LEL)
UPPER EXPLOSIVE LIMIT (UEL)

These mixtures will also have different: auto-ignition temperatures (AIT); minimum ignition currents (MIC - intrinsic safety test apparatus); maximum experimental safe gaps (MESG - relates to flameproof enclosures flame path), depending upon the substances contained within the mixture.

EXAMPLES OF EXPLOSIVE MIXTURES

Substance	LEL (%)	UEL (%)	MESG mm	MIC mA	AIT (°C)
Methane	5	15	1.14	195	595
Propane	2	9.5	0.97	146	470
Ethylene	2.7	34	0.65	108	425
Acetylene	3	17	0.25	60	305
Hydrogen	4	75.6	0.28	75	560

Figure 2. Examples of Explosive Mixtures

It is evident from the limited list shown in the table above that there are some natural groupings for the gases based on their MESG and MIC values.

These groups are divided into two groups;

Group I for mines susceptible to methane.
Group II for explosive gases for locations other than coal mines; group II is further divided into three sub groups:
    IIA, for atmospheres containing propane or gases of an equivalent hazard.
    IIB, for atmospheres containing ethylene or gases of an equivalent hazard.
    IIC, for atmospheres containing hydrogen or gases of an equivalent hazard.

(Extensive listings have been published which details thousands of different gases and their associated groupings.)

The natural grouping of the gases based upon the MESG and MIC values does not bear any relationship to the auto-ignition temperatures (AIT) of the various substances.

The auto-ignition temperature is the temperature, in °C, at which a gas will ignite spontaneously without another source of ignition. Because these temperatures do not correspond with the above groupings, a temperature code was established. The resulting temperature codes for the substances listed above (temperature classification) are shown in the table below.

TEMPERATURE CODES

The full list of temperature codes are listed in the table below:

Substance	Temperature Classification
Methane	T1
Propane	T1
Ethylene	T2
Acetylene	T2
Hydrogen	T1

Figure 3. Full List of Temperature Codes

The gas groupings and the temperature codes are reflected in the markings that appear on electrical equipment, which has been certified for use in a hazardous area. The marking of the gas grouping and temperature code on the equipment identifies to the user the type of explosive atmosphere in which it can be safely installed (see Section 4 for further details).

Hazardous areas are further divided in zones, these zones relate to the predicted occurrence of when an explosive atmosphere may be present in the area. These zones are defined as being:

ZONE 0, where an explosive atmosphere is continuously present, or present for long periods.
ZONE 1, where an explosive atmosphere is likely to occur in normal operation.
ZONE 2, where an explosive atmosphere is not likely to occur in normal operation and if it does occur it will exist only for a short time.

Commonly recognised concepts of protection

There are eight commonly recognised concepts of protection within Europe. These are detailed in the European EN60079 series of Standards; 'electrical equipment for use in explosive atmospheres'. These methods of protection have, over the years, been added to and expanded to satisfy the new equipment designs that have appeared.

GENERAL REQUIREMENTS

BS EN 60079 series of standards has been written for manufacturers of electrical equipment for use in gas explosive atmospheres.

Unless modified by one of the parts in the IEC 60079 series, electrical apparatus complying with this standard is intended for use in hazardous areas in which explosive gas atmospheres, caused by mixtures of air and gases, vapours or mists, exist under normal atmospheric conditions of:

temperature –20 °C to +60 °C;
pressure 80 kPa (0,8 bar) to 110 kPa (1,1 bar); and
air with normal oxygen content, typically 21 % v/v.

The application of electrical apparatus in atmospheric conditions outside this range may need special consideration.

FLAMEPROOF

BS EN 60079 Part 1 Electrical apparatus for explosive gas atmospheres, Flameproof enclosures'd'.

Requirements for the construction and testing of electrical apparatus with protection flameproof enclosure'd'.

This part of EN 60079 contains specific requirements for the construction and testing of electrical apparatus with the type of protection flameproof enclosure'd', intended for use in explosive gas atmospheres.

This European Standard covers supplementary requirements for shafts and bearings, breathing and draining devices which form part of flameproof enclosures, fasteners, associated holes and closing devices, materials and mechanical strength of enclosures, verification and tests, and non-metallic enclosures and non-metallic parts of enclosures.

INTRINSIC SAFETY

BS EN 60079:2007 Part 11 Electrical apparatus for explosive gas atmospheres: Intrinsic Safety ia and ib

Specifies the construction and testing of intrinsically safe apparatus intended for use in an explosive gas atmosphere and for associated apparatus that is intended for connection to intrinsically safe circuits that enter such atmospheres.

This type of protection is applicable to electrical apparatus in which the electrical circuits themselves are incapable of causing an explosion in the surrounding explosive atmospheres.

This standard is also applicable to electrical apparatus or parts of electrical apparatus located outside the explosive gas atmosphere or protected by another type of protection listed in BS EN 60079-0, where the intrinsic safety of the electrical circuits in the explosive gas atmosphere may depend upon the design and construction of such electrical apparatus or parts of such electrical apparatus. The electrical circuits exposed to the explosive gas atmosphere are evaluated for use in such an atmosphere by applying this standard.

BS EN 60079-11:2007 replaces BS EN 60079-11:2002 which will be withdrawn.

This design concept is reflected in the equipment marking by the symbols 'Ex ia' or 'Ex ib'. Equipment designed to this concept is suitable for use in: 'Ex ia' 'Zone 0', 'Zone 1' and 'Zone 2'; 'Ex ib' 'Zone 1' and 'Zone 2' classified hazardous areas.

PRESSURISATION

BS EN 60079 Part 2 Electrical apparatus for explosive gas atmospheres, Pressurised enclosures 'p'.

BS EN 60079-2 contains the specific requirements for the construction and testing of electrical apparatus with pressurised enclosures, of type of protection "p", intended for use in explosive gas atmospheres.

BS EN 60079-2 specifies requirements for pressurised enclosures containing a limited release of a flammable substance. The standard gives requirements for the design, construction, testing and marking of electrical apparatus for use in potentially explosive atmospheres in which:

a) a protective gas maintained at a pressure above that of the external atmosphere is used to guard against the formation of an explosive gas atmosphere within enclosures which do not contain an internal source of release of flammable gas or vapour; and, where necessary.

b) a protective gas is provided in sufficient quantity to ensure that the resultant mixture concentration around the electrical parts is maintained at a value outside the explosive limit appropriate to the particular conditions of use. The protective gas is supplied to an enclosure containing one or more internal sources of release in order to guard against the formation of an explosive gas atmosphere.

BS EN 60079-2 includes requirements for the apparatus and its associated equipment including the inlet and exhaust ducts, and also for the auxiliary control apparatus necessary to ensure that pressurisation and/or dilution is established and maintained.

This design concept is reflected in the equipment marking by the symbol 'Ex p'. Equipment designed to this concept is suitable for use in 'Zone 1' and 'Zone 2' classified hazardous areas.

INCREASED SAFETY

BS EN 60079 Part 7 Electrical apparatus for explosive gas atmospheres, Increased safety 'e'.

BS EN 60079-7 specifies the requirements for the design, construction, testing and marking of electrical apparatus with type of protection increased safety ‘e’ intended for use in explosive gas atmospheres. This standard applies to electrical apparatus where the rated voltage does not exceed 11kV rms a.c. or d.c. Additional measures are applied to ensure that the apparatus does not produce arcs, sparks, or excessive temperatures in normal operation or under specified abnormal conditions.

This design concept is reflected in the equipment marking by the symbol ‘Ex e’. Equipment designed to this concept is suitable for use in ‘Zone 1’ and ‘Zone 2’ classified hazardous areas.

Type N Protection (Non-sparking)

BS EN 60079 Part 15 Electrical apparatus for explosive gas atmospheres, Type of protection ‘n’.

A type of protection applied to an electrical apparatus such that, in normal operation, it is not capable of igniting a surrounding explosive atmosphere, and a fault capable of causing ignition is not likely to occur.

This design concept is reflected in the equipment marking by the symbol ‘Ex n’. Equipment designed to this concept is suitable for use in ‘Zone 2’ classified hazardous areas.

Note that in the long term the protection concepts used in this standard are being incorporated into the individual protection concept standards.

For e.g. Ex nL (energy limitation) is now identified as Ex ic and incorporated into the Intrinsic Safety standard, EN 60079 Part 11

OIL IMMERSION

BS EN 60079 Part 6 Electrical apparatus for potentially explosive atmospheres, Oil immersion ‘o’.

A method of protection where the electrical apparatus is made safe by oil immersion, in the sense that an explosive atmosphere above the oil or outside the enclosure will not be ignited. The oil presents a barrier between the explosive atmosphere and the electrical apparatus.

This design concept is reflected in the equipment marking by the symbol ‘Ex o’. Equipment designed to this concept is suitable for use in ‘Zone 1’ and ‘Zone 2’ classified hazardous areas.

POWDER/ SAND FILLING

BS EN 60079 Part 5 Electrical apparatus for potentially explosive atmospheres, Powder filling ‘q’.

A method of protection where the enclosure of the electrical apparatus is filled with a mass of granular material such that, if an arc occurs the arc will not be liable to ignite the external explosive atmosphere.

This design concept is reflected in the equipment marking by the symbol ‘Ex q’. Equipment designed to this concept is suitable for use in ‘Zone 1’ and ‘Zone 2’ classified hazardous areas.

ENCAPSULATION

BS EN 60079 Part 18 Electrical apparatus for explosive gas atmospheres, Construction, test and marking of type of protection encapsulation ‘m’ electrical apparatus.

A type of protection in which parts that could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that the explosive atmosphere cannot be ignited. The compound provides a barrier between the electrical apparatus and the explosive atmosphere.

BS EN 60079-18 gives the specific requirements for the construction, testing and marking of electrical apparatus, parts of electrical apparatus and Ex components with the type of protection encapsulation 'm'.

This part only applies for encapsulated electrical apparatus, encapsulated parts of electrical apparatus and encapsulated Ex components where the rated voltage does not exceed 10 kV with a relative tolerance of +10%.

This design concept is reflected in the equipment marking by the symbol ‘Ex ma or Ex mb, designated against equipment designed for use in ‘Zone 0’ and ‘Zone 1 classified hazardous areas respectively.

Electrical Equipment Marking

The electrical equipment that has been assessed and tested and, found to be in compliance with the relevant European Harmonised Standard is marked with the certification coding as described in the aforementioned standards.

CERTIFICATION CODING EXAMPLE

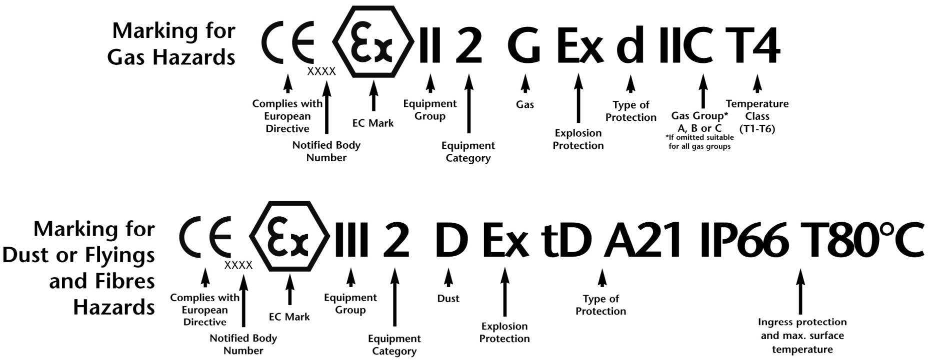

Figure 4. Certificate Coding Example

The marking details will also include the certificate number issued by the certification body.

CERTIFICATE NUMBER EXAMPLE

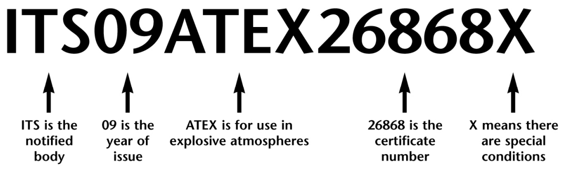

Figure 5. Certificate Number Example

The equipment marking, assuming full compliance with the relevant standard/s is met, will also include the Hexagon Ex symbol, the affixing of this symbol enables the equipment to be sold and installed freely within Europe.

Figure 6. Hexagon Ex Symbol

From July 1st 2003 equipment manufactured for use in Hazardous Areas must be ATEX certified in order to carry the ‘CE Mark’. (CE marking is a declaration by the manufacturer that the product meets all the appropriate provisions of the relevant legislation implementing certain European Directives. CE marking gives companies easier access into the European market to sell their products without adaptation or rechecking. The initials "CE" do not stand for any specific words but are a declaration by the manufacturer that his product meets the requirements of the applicable European Directive(s).)

The implementation and use of mechanical or electrical product on the market in Europe after this date that is designed to be used in a potentially explosive dust or gas atmosphere will be subject to compliance with the ATEX Directive and will be mandatory by law.