Beamex

Calibration White Paper

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Calibration in hazardous areas

WORLD-CLASS CALIBRATION SOLUTIONS

Calibration in hazardous areas

This article discusses calibration in hazardous areas and what everyone needs to be aware of before entering into a hazardous area with calibration equipment. Other topics covered are flammable and combustible liquids, definition of a hazardous area, the types of industries where hazardous areas are found, the different levels of hazardous zones, regulations, equipment classification and various other practical and related issues.

There are many different levels of hazardous areas. There are also many different types of Ex-rated calibration equipment.

Fast forward bullets:

- What is a hazardous area?
- Brief explanation of related legislation
- Which Ex calibration equipment can be taken into an Ex area?

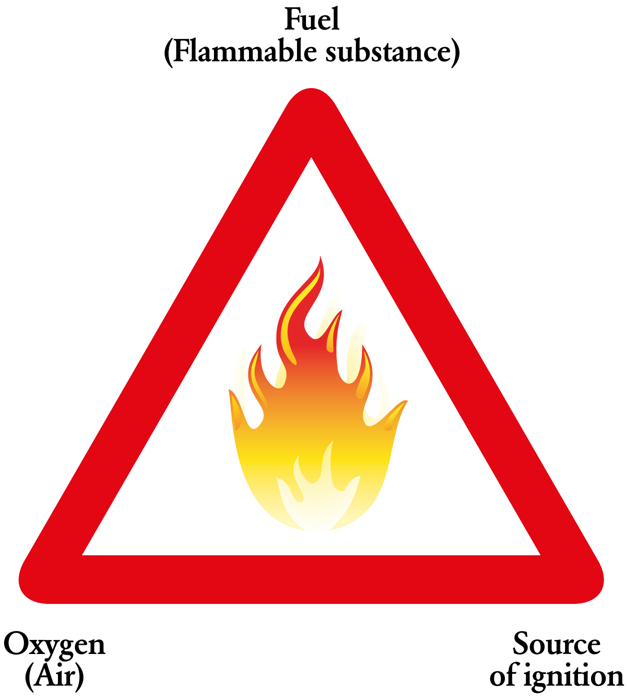
What is a hazardous area?

A hazardous area is an area (indoors or outdoors) that contains, or may contain, flammable substances. The flammable substance may be a liquid, gas, vapor or dust. The area may contain a flammable substance all of the time, most of the time, or only in specific situations, such as during shut-downs or accidents.

> Many times, eliminating the flammable substance is not possible, and therefore the oxygen (air) or source of ignition has to be eliminated.

In such a hazardous area, an explosion or fire is possible if all three conditions of the "Explosion Triangle" (below) are met. These three conditions are fuel (a flammable substance), source of ignition (or heat) and oxygen (air). The situation is often presented as a triangle; hence the name Explosion Triangle.

Explosion Triangle:



Brief history of hazardous areas

Keeping in mind the Explosion Triangle, we can conclude that one or more of the three elements must be eliminated. Many times, eliminating the flammable substance is not possible, and therefore the oxygen (air) or source of ignition has to be eliminated. However, it is also often impossible to eliminate the air. Therefore, the most practical solution is to eliminate the source of ignition, spark or heat.

In the case of electrical calibration equipment, it can be specially designed to use in hazardous areas. There are many ways to design electrical equipment suitable for hazardous areas and this topic will be discussed later on. Calibration equipment is often designed in such a way that it cannot provide enough energy to cause the source of ignition, spark or heat.

Brief history

Some of the first hazardous areas were discovered in the early coal mines. Being flammable substances, both the coal dust and the methane absorbed created a hazardous area. The lighting in early mines was produced by candles and torches, generating a source of ignition. This led to many accidents.

Later, when miners began to use electrical equipment (lighting, tools), many accidents occurred due to sparking or heating. Eventually, design standards were developed to guide the design process to prevent the sparking and heating of electrical equipment. This was the first "intrinsically safe" electrical equipment and it led the way to the standards compiled for equipment used in hazardous areas today.

Typical industries with hazardous areas

There are many industries that have hazardous areas. Some plants have large hazardous areas, while others have only small sections classified as hazardous areas. Typical industries with hazardous areas include chemical and petrochemical industries, offshore and on-shore oil and gas, oil refining, the pharmaceutical industry, food and beverage, energy production, paint shops and mining.

Since a flammable substance may be a liquid, gas, vapor or dust, there are surprisingly many different industries that may have some areas where these substances may be present during the normal operation or during shut-down. Even some seemingly safe industries may have hazardous areas.

In plants, all areas classified as hazardous should be clearly marked with the Ex logo:

Flammable and combustible liquids

There is often discussion about flammable and combustible liquids. But what are they precisely? Generally speaking, they are liquids that can burn. They may be gasoline, diesel fuel, many solvents, cleaners, paints, chemicals, etc. Some of these liquids are present in many workplaces.

Flashpoint and autoignition temperatures are also often discussed. Flashpoint is the lowest temperature of a liquid at which it produces sufficient vapor to form an ignitable mixture with air. With a spark or enough heat, it will ignite. Autoignition temperature is the lowest temperature at which a liquid will ignite even without an external source of ignition. Most commonly, flammable and combustible liquids have autoignition temperatures in the range of 572 °F to 1022 °F (300 °C to 550 °C). However, there are liquids that have an auto-ignition temperature as low as 392 °F (200 °C) or less.

Often 100 °F (37.8 °C) is considered as the temperature limit. Flammable liquids have a flashpoint below 100°F and combustible liquids above.

Based on their flashpoint, liquids are classified as flammable or combustible. Flammable liquids may ignite at normal working temperatures, while combustible liquids burn at higher temperatures. Often 100 °F (37.8 °C) is considered as the temperature limit. Flammable liquids have a flashpoint below 100 °F and combustible liquids above.

To be more precise, flammable and combustible liquids themselves do not burn, it is the vapors that burn. More precisely, it is the mixture of the vapors and air that burns. There are also limits of the concentration within which the mixture can burn. If the concentration of the mixture is too low (too thin) it will not burn; the same is true if the concentration is too high (too rich). The limits are known as lower and upper explosive limits (LEL and UEL).

It is good to remember that some liquids may have a rather low flashpoint. For example, gasoline has a flashpoint as low as c. -40 °F (-40 °C). It produces enough vapors in normal environmental conditions to make a burnable mixture with air. Combustible liquids have a flashpoint way above normal environmental conditions, and therefore they have to be heated before they will ignite.

Some examples of flashpoint and autoignition temperatures:

Substance	Flashpoint	Autoignition temperature
Ethylene	-276.8 °F (-136 °C)	914 °F (490 °C)
Propane	-155.2 °F (-104 °C)	878 °F (470 °C)
Butane	-76 °F (-60 °C)	550.4 °F (288 °C)
Diethyl ether	-113 °F (-45 °C)	320 °F (160 °C)
Ethanol	61.9 °F (16.6 °C)	685.4 °F (363 °C)
Gasoline	-45.4 °F (-43 °C)	536 °F (280 °C)
Diesel	143.6 °F (62 °C)	410 °F (210 °C)
Jet fuel	140 °F (60 °C)	410 °F (210 °C)
Kerosene	100 to 162 °F (38 to 72 °C)	428 °F (220 °C)

Various protective techniques

As mentioned earlier, in order to prevent an explosion, one of the three elements of the Explosion Triangle should be eliminated. In practice, eliminating the source of ignition would be the most sensible.

There are various techniques in electrical equipment that make them safer for hazardous areas. These different techniques fall into two main categories: eliminate the source of ignition (Exe, Exi) or isolate the source of ignition (Exd, Exp, Exq, Exo, Exm).

Intrinsically safe equipment is designed so that in any situation, even in the case of a faulty device, the device will not provide enough energy to generate sparks or surface temperatures that are too high.

The table below briefly describes some of these different techniques:

Technique	Marking on equipment	Description
Exe	e	Increased safety
Exi	i	Intrinsically safe
Exn	n	Non incendive
Exd	d	Flameproof
Exp	p	Pressurized
Exq	q	(Sand/quartz) filled
Exo	o	Oil filled
Exm	m	Encapsulated

The table also describes the letter that is written on the equipment classification. For example, a device with the Intrinsically Safe technique will have the “Exi” label.

Intrinsically safe technique

The Exi “Intrinsically Safe” technique is the most commonly used and most suitable protective technique for electrical calibration equipment. Intrinsically Safe equipment is designed for any situation; it will not provide enough energy to generate sparks and excessively high surface temperatures, even in the case of a faulty device. The equipment is designed to be intrinsically safe.

Inside an Exi device, the Exm (“Encapsulated”) technique may also be used for certain parts of the equipment (as in a battery pack).

“Hot work permit”

Using non-Ex calibration equipment in a hazardous area may be possible, but it requires special approval from the safety personnel in the factory. Oftentimes, this also involves the use of safety devices, such as personal portable gas detectors, to be carried in the field while working. Using equipment rated Ex correctly is easier, as it does not require any special approvals. Naturally, the Ex-rated calibration equipment must be suitable for the hazardous area to which it is taken.

International / North American legislation and differences

There are two different standardizations specifying hazardous areas and classification of the equipment used in hazardous areas. One is the International IEC standard and the ATEX directive used in International and European legislation. The second is the North American legislation.

As there are some differences between these two, this article looks, first, at the two separately and then makes a comparison of them.

International IEC standards, IECEx scheme and ATEX directive

The international standard family of IEC 60079 defines the different standards for related regulations.

The IECEx scheme involves international co-operation based on the IEC standards. The objective of the IECEx system is to facilitate international trade in equipment and services for use in explosive atmospheres, while maintaining the required level of safety. Today, there are approximately 30 member countries in the IECEx, including the USA.

The ATEX directive was introduced to unify hazardous equipment and work environments within the European Union. It was established about 10 years ago and is based on the directives introduced in the 90s.

Hazardous zones classification

The zone classification specifies how likely it is for a certain flammable substance to occur in the atmosphere in a certain area.

The classification has been developed to specify the different hazardous areas (Zones):

Zone (gas, vapor)	Zone (dust)	Description
Zone 0	Zone 20	Area in which an explosive substance in the atmosphere is present continuously or for long periods or frequently.
Zone 1	Zone 21	Area in which an explosive substance in the atmosphere is likely to occur in normal operation occasionally.
Zone 2	Zone 22	Area in which an explosive substance in the atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Product category and Equipment Protection Levels (EPL)

In ATEX-directive Group II, equipment is divided into product categories specifying the use of the equipment in different zones. The product categories of the Group II equipment are specified as following:

- **Product category 1**
– Very high safety level. Can be used even in Zone 0 (and Zone 1 & 2).
- **Product category 2**
– High safety level. Can be used in Zone 1 and 2 (but not in Zone 0).
- **Product category 3**
– Normal safety level. Can be used in Zone 2 (but not in Zones 0 & 1).

The zone classification specifies how likely it is for a certain flammable substance to occur in the atmosphere in a certain area.

In the IEC standards, the same thing is expressed using EPLs (Equipment Protection Level). EPLs are specified using nearly the same categories:

- **EPL a**
– Very high safety level. Can be used even in Zone 0 (and Zone 1 & 2).
- **EPL b**
– High safety level. Can be used in Zone 1 and 2 (but not in Zone 0).
- **EPL c**
– Enhanced safety level. Can be used in Zone 2 (but not in Zones 0 & 1).

The relationship between the product categories/EPLs and hazardous zones:

Product category label	EPL marking	Hazardous zone	Flammable substance	Can also be used in hazardous zone
1G	a or Ga	0	Gas, vapor	1 and 2
2	b or Gb	1	Gas, vapor	2
3	c or Gc	2	Gas, vapor	-
1	a or Da	20	Dust	21 and 22
2	b or Db	21	Dust	22
3	c or Dc	22	Dust	-

A product category 1/EPL a device (can be used in Zones 0, 1 and 2) is safe even in the event of two simultaneous faults in the device. This means that all protective safety circuits are tripled. A category 2/EPL b device has doubled safety circuits and can be used in Zones 1 and 2. Category 3/EPL c devices have single safety circuits and can be used in Zone 2 only.

According to the table above, if there is a need to use electrical equipment in a hazardous area classified as Zone 1, the product category 1 and 2 equipment can be used. If the area is Zone 0, only equipment in product category 1 is allowed. Again, if the Zone is 2, any product category (1, 2 or 3) equipment is allowed.

A product in category 1 has the number 1 in its ATEX marking , for example “II 1 G”. It also has a letter “a” in its marking for EPL, for example “Ex ia”.

Consequently, it is important to know the zones where the calibration equipment will be used and select the equipment accordingly.

Equipment grouping

Electrical equipment for explosive atmospheres according to the IEC 60079-0 standard is divided into the following groups:

Group I

Electrical equipment in Group I is intended for use in mines susceptible to firedamp.

Group II

Electrical equipment in Group II is intended for use in places with an explosive gas atmosphere other than mines susceptible to firedamp.

Electrical equipment in Group II is subdivided according to the nature of the explosive gas atmosphere for which it is intended.

Group II subdivisions
- IIA, a typical gas is propane
- IIB, a typical gas is ethylene
- IIC, a typical gas is hydrogen

This subdivision is based on the maximum experimental safe gap (MESG) or the minimum ignition current ratio (MIC ratio) of the explosive gas atmosphere in which the equipment may be installed (see IEC 60079-20-1).

Equipment marked IIB is suitable for applications requiring Group IIA equipment. Similarly, equipment marked IIC is suitable for applications requiring Group IIA or Group IIB equipment.

Group III

Electrical equipment in Group III is intended for use in places with an explosive dust atmosphere other than mines susceptible to firedamp.

Electrical equipment in Group III is subdivided according to the nature of the explosive dust atmosphere for which it is intended.

Group III subdivisions:
- IIIA: combustible flyings
- IIIB: non-conductive dust
- IIIC: conductive dust

Equipment marked IIIB is suitable for applications requiring Group IIIA equipment. Similarly, equipment marked IIIC is suitable for applications requiring Group IIIA or Group IIIB equipment.

Temperature Class

The temperature class specifies the maximum surface temperature in the equipment. The temperature class is important to take into account and assure that it matches with the flammable gas that may be present in the plant's own hazardous area.

The temperature classes and temperatures are the following:

Temperature Class	Maximum surface temperature
T1	842 °F (450 °C)
T2	572 °F (300 °C)
T3	392 °F (200 °C)
T4	275 °F (135 °C)
T5	212 °F (100 °C)
T6	185 °F (85 °C)

Some equipment may also have a maximum surface temperature specified as a certain temperature being in between the classes.

Depending on the type of flammable substance in a certain area, the flashpoint and auto-ignition temperatures will be different. The equipment selected to be used in that hazardous area must have a temperature classification that suits the substances in question.

The temperature class of a device is included in its marking, for example "T4".

North American legislation differences: Divisions

While in the IEC standard the hazardous areas are divided into zones, the North American system divides them into divisions. While numbers 0 to 2 are used in zones, numbers 1 and 2 are used in divisions. Zones 0 and 1 both are covered by Division 1.

The table below compares the Zones and Divisions:

Zone	Division	Description
Zone 0	Division 1	Area in which an explosive substance in the atmosphere is present all the time.
Zone 1	Division 1	Area in which an explosive substance in the atmosphere is present in normal operation.
Zone 2	Division 2	Area in which an explosive substance in the atmosphere is present only in abnormal operation.

The following is a brief summary of the relationship between the product categories/EPLs and hazardous area zones (IEC) and divisions (North America):

Product Category/EPL	Zone	Division
1/a	0	1
2/b	1	1
3/c	2	2

Explosion group

The North American legislation has one more explosion/equipment group compared to the IEC. The comparison of the explosion groups (gas) of the North American and IEC are shown in the table below:

IEC	North America
IIC – Acetylene / Hydrogen	A – Acetylene B – Hydrogen
IIB – Ethylene	C – Ethylene
IIA – Propane	D – Propane

The most dangerous explosion group is identified as A in North America, while it is IIC in the IEC system.

The most dangerous explosion group is identified as A in North America, while it is IIC in the IEC system.

Temperature class

In the North American system, there are more intermediate temperature classes.

The table below shows a comparison between the IEC/ATEX and North American temperature classes:

IEC/ATEX	North American	Max temperature
T1	T1	842 °F (450 °C)
T2	T2	572 °F (300 °C)
T2	T2A	536 °F (280 °C)
T2	T2B	500 °F (260 °C)
T2	T2C	446 °F (230 °C)
T2	T2D	419 °F (215 °C)
T3	T3	392 °F (200 °C)
T3	T3A	356 °F (180 °C)
T3	T3B	329 °F (165 °C)
T3	T3C	320 °F (160 °C)
T4	T4	275 °F (135 °C)
T4	T4A	248 °F (120 °C)
T5	T5	212 °F (100 °C)
T6	T6	185 °F (85 °C)

Environmental conditions

Finally, it is important to ensure that the equipment is suitable for the environmental conditions where it will be used. For example, the safe operating temperature of the device must match the temperature in which the equipment is used in a plant. In wet and dusty conditions, the protection rating of the equipment casing needs to be considered; this can be classified IP (Ingress Protection) or NEMA. Different protective techniques may require different classification on the casing.

It is also important to remember that the casing of some Ex equipment is made out of non-static (semi-conducting) material to avoid accumulation of any static electricity. Depending on the classification, there are limits on the size (static) of labels that can be put onto the device. For example, Group I equipment, for Zone 0, with gas Group IIC, may have a label sizing an area of maximum 4 cm^2 (0.6 $inch^2$). It is important to keep that in mind before attaching any identification labels on Ex equipment.

Example of equipment marking

The example is an intrinsically safe process calibrator, model Beamex MC5-IS. This is a multifunctional portable process calibrator, which can be used in hazardous areas.

The product has the Ex marking Ex II 1 G, Ex ia IIC T4 Ga (Ta = -4 to 122 °F (-20 to 50 °C)).

That marking is also shown in the picture as it would be on the face of the device.

The Ex marking code and what it indicates in practice:

	Description
Ex	Ex-certified product
II	Equipment group II (non-mining)
1	Product category 1 (can be used in zone 0)
G	Explosive atmosphere caused by gases
Ex	Ex-certified product
ia	Intrinsically safe (i), level of protection ia
IIC	Application above ground (II), Gas group C
T4	Temperature class
Ga	EPL Equipment protection level Ga
Ta	Safe operating temperature

Beamex MC5-IS

Marking on Beamex MC5-IS