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Electrical Equipment and Installations in Hazardous Areas

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1

Introduction

Our Industry free from injuries and accidents.

Industrial accidents are as old as industry itself and so are preventive measures. The Standards for Explosive Areas or Atmospheres have also evolved diversely worldwide, based on the local needs of the industries for the overall safe operation of the plants.

Explosion and fire are two of the major constituents of these mishaps. Depending upon the environment, these can be termed 'Accidents' or fade away as simply 'incidents' or 'Near Misses' in the safety officers' statistics.

The first step logically is to start defining and understanding some of the terms used in the whole scope of the loss prevention in accidents due to explosion and fire.

FIRE is a rapid oxidation–reduction reaction (combustion) which results in the production of heat and generally visible light.

EXPLOSION is a violent and sudden expansion of gases produced by rapid combustion; that very strong force when shut in a small space and generally associated with a loud, sharp noise and a supersonic shock wave.

For example – bursting of balloons, boiler explosion, combustion of a gas mixture, detonation of high explosives.

Invariably, electricity is required to run the production processes in any industry. The fundamental nature of electricity to create a spark or generate energy leads to a situation where, in an 'explosive atmosphere', ignition is triggered leading to explosion or fire.

An explosion occurs when there is a confluence of the three basic elements:

- 1) Fuel, any combustible material
- 2) Oxygen, generally available for free in nature as 21% in air. It can also be supplied by oxidizers such as acids
- 3) Ignition source – chemical, mechanical, nuclear or electrical.

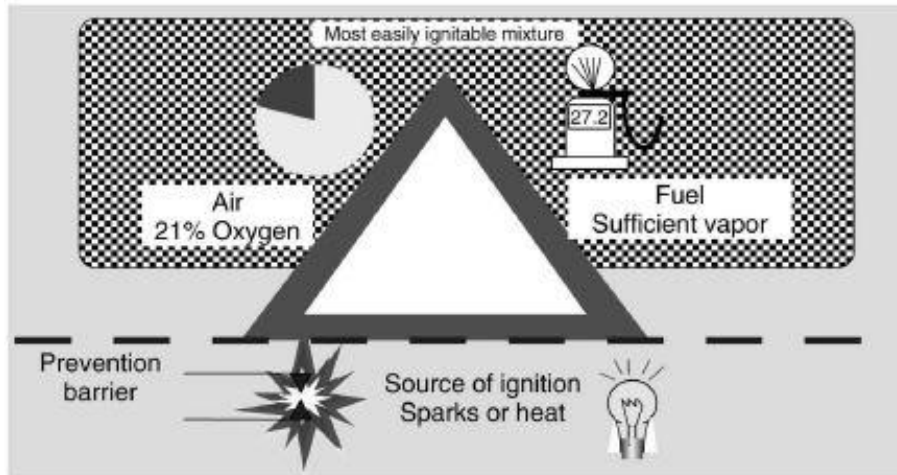


Figure 1. The hazard triangle

The technology is currently based on the identification of the risk of an explosive atmosphere being present in a particular place. The objectives are not just to identify these coincidences but to utilize the information so obtained to influence the design of particular process plants and similar operational situations.

In this approach, the areas normally prone to have an explosive atmosphere, due to the requirement of various processes involved, are identified. Similarly, the areas where its probability is low but identifiable are marked up.

This is not an end in itself but should be deployed as a part of 'overall safety strategy' for the plant. Once the potential hazardous areas are identified and marked-up, only the minimum number of justifiable, necessary and essentially required electrical equipment/appliances/installations are housed in these identified areas. These are then so protected as to render the overall risk of explosion sufficiently low.

2

Area Classification of Hazardous Areas

What is Area Classification, in relation to hazardous areas?

The process list and identify the areas in the plant where there is possibility of a conducive atmosphere for explosion or fire to occur. The design, selection and operation of the equipment has to be influenced in such a way that the risk of fire or explosion taking place is minimized.

The area classification needs to be used as a tool to achieve the ultimate objective of ensuring overall plant safety and minimizing the risk of loss to life and property.

The balance needs to be struck between presence of an explosive and ignitable environment in an unrestricted area, and the limits prescribed for its classification, because a too-conservative approach may make the whole exercise so costly that the viability of the project might be questioned.

It is useful to understand what a non-hazardous (unrestricted) area is. An area classified as non-hazardous has a small probability of a flammable mixture being present.

2.1 Safety principles

Hazard and operability studies are carried out during initial design, renovation and modernization stages. These need to be followed up with 'periodic risk assessment studies' during operation of the plant.

The 'safety first' principle dictates that the quantity of release of flammable material in and around electrical installations is to be kept to a minimum, in case it is not possible to eliminate it, so that the extent of area under influence of hazardous classification is also kept to a minimum.

Even in emergency conditions, emphasis should be placed on weeding out and eliminating the root cause of the manifestation of ignitable or combustible atmosphere, i.e.

- Disconnection or isolation of defective electrical equipment;
- Shutdown of processes;
- Isolation of process vessels having ignitable material;
- Containment of spillage.

Then a review needs to be done to augment with additional ventilation, wherever the process and location of the installation permit, to quickly reduce the intensity of hazardous atmosphere or environment.

Safety and minimization of risk to life and property demand,

- That ignitable, explosive or hazardous environments be isolated from the 'ignition source';
- That the source of ignition be eliminated.

Whenever it is not possible to reliably and safely implement at least one of the above, then steps should be taken to put in place procedures whereby the operations are implemented in such a way so as to minimize the above conditions occurring simultaneously to an acceptable safe level.

2.2 Hazards and hazardous areas

Hazards can be:

- Urban structure fires;
- Boiling liquid expanding vapor explosions;
- Other explosions;
- Toxic emission;
- The use of electrical equipment in the vicinity of water;
- The risk of personal injury from moving or falling parts;
- The presence of biological hazards.

The determination that areas can be classified as hazardous locations is based on the following:

- The possible presence of an explosive atmosphere such as flammable gases, vapors or liquids, combustible dusts or ignitable fibers and flyings;
- The probability that the explosive atmosphere is present when equipment is operating;
- The ignition-related properties of the explosive atmosphere that is present.

2.3 Basis of area classification

Area classification cannot be set rigidly into any standard. Each installation will be different in some respect and therefore each site must be examined on its individual merits.

There are three situations that can occur in an operating plant with reference to hazardous areas:

- 1) A situation where an explosive atmosphere is present always or for long periods because of operational requirement, i.e. *continuous*.
- 2) A situation where explosive atmosphere occurs frequently, or if infrequently may persist for a considerable time, i.e. *primary*.
- 3) A situation in which explosive atmosphere occurs rarely and normally result from failure of equipment or procedures, i.e. *secondary*.

The above criteria are used in classifying the areas under 'Source of Release' methodology of classification.

2.4 Zonal Classification

Hazardous places are classified in terms of zones on the basis of the frequency and duration of the occurrence of an explosive atmosphere. The higher the number in this 'zonal classification' the smaller is the risk of an explosion.

2.4.1 Gases, vapor and mists

For gases, vapours and mists the zone classifications are:

Zone 0	A place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
Zone 1	A place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
Zone 2	A place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Table 1. Gases, vapours and mists zone classifications

2.4.2 Dusts

For dusts the zone classifications are:

Zone 20	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
Zone 21	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur in normal operation occasionally.
Zone 22	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Table 2. Dusts zone classifications

3

Design Philosophy for Equipment and installations

The use of electricity in potentially explosive areas has been a concern since the beginning of the 20th century, when these areas were encountered in mines. To avoid the danger of explosions, protective regulations in the form of laws, specifications and standards have been developed in most countries and are aimed at ensuring that a high level of safety is observed. Due to growing international economic links, extensive progress has been made in harmonizing the regulations for explosion protection.

In mining, miners underground have always lived under the threat of firedamp explosions. Herein lies the origin of explosion protection, which has been consistently developed in industrialized countries and now provides a high level of safety.

The hazardous areas can vary greatly in size, based on explosive fuel, or use of equipment. The explosive atmosphere may contain fumes, dust or fibers. Therefore, it becomes imperative to look into the constructional details of electrical equipment to be installed in hazardous areas, in order to minimize the risk of fire or explosion. It is to be noted that despite how well the construction is, there always remains a residual risk, however small it may be.

Electrical installations in hazardous areas, involve high initial capital costs on methods of safeguarding and continuing high inspection and maintenance costs relative to comparable installations in non-hazardous areas.

Engineers have, that way, a special responsibility, if need be by influencing basic plant layout and design, to ensure that the need for electrical apparatus in hazardous areas is kept to a minimum.

Where the installation of electrical apparatus in hazardous areas is unavoidable, special methods of safeguarding must be adopted to avoid danger.

3.1 Equipment definition

The term 'equipment' is defined as:

Any item which contains or constitutes a potential ignition source and which requires special measures to be incorporated in its design and/or its installation in order to prevent the ignition source from initiating an explosion in the surrounding atmosphere.

Also included in the term 'equipment' are safety or control devices installed outside the hazardous area but having an explosion-protection function. 'Protective systems' are defined as items that prevent an explosion that has been initiated from spreading or causing damage. They include flame arresters, quenching systems, pressure-relief panels and fast-acting shut-off valves.

Equipment is classified according to:

- The maximum (spark) energy it can produce;
- Its maximum surface temperature.

For equipment to be considered safe for use on a plant, the categories of classification on the equipment must be the same or 'better' than that required by the plant. The statement of the categories to be encountered on a plant (by its owner or user) provides any potential supplier of equipment (or contractor) with a clear understanding of the limits that must not be exceeded if the equipment is to be operated safely. The suppliers may have their equipment tested for conformance with these limits and then gain official approval or certification for those categories met. In this way, the system helps to match plant and equipment together in a safe way.

The nature of the explosive atmosphere	This relates to the characteristics of the gas(es) or dusts likely to be encountered. In order not to ignite it, there is a maximum spark or flame energy level as well as a maximum surface temperature that must not be exceeded
The probability that an explosive mixture is present	This requires an assessment of where and when gas or dust could accumulate in sufficient concentrations and/or layers, respectively
The maximum energy that can be produced	This relates to the ‘apparatus group’ of the equipment. This must be matched to the nature of the explosive atmosphere that the equipment may encounter
The maximum surface temperature	This relates to the ‘temperature class’ of the equipment. This must be matched to the nature of the explosive atmosphere that the equipment may encounter

Table 3. Match plant and equipment

3.2 Apparatus grouping

The ‘apparatus grouping’ concept originally emerged during the development of the surface industries when a greater range of chemical processes began to use flammable materials.

The mining industry recognized and took precautions against the risk of flammability but only had one gas to contend with, methane. The methane purity varied and so tests were plan to verify which purity of the methane was the easiest to ignite. Thus was found the form known as firedamp owing to its relatively high hydrogen concentration. This became the gas used in the testing of electrical equipment to be used in mining. Equipment was only ever tested for the ignition of firedamp on the basis that if the equipment could not ignite this gas then it could not ignite any other form that was more difficult to ignite.

Many different gases or vapors could be in use in industries above ground (referred to as surface industries). Each gas or vapor has its own characteristics and originally equipment was tested for the specific gas it was likely to encounter when in service. It would therefore be impractical to individually type-test apparatus to determine in which gases it was safe or unsafe.

Consequently, a grouping system was developed. Electrical equipment for explosive gas atmosphere is now grouped according to the type of industry in which they are used:

Group I	Electrical equipment for underground industries (mining) susceptible to methane
Group II	Electrical equipment for all places with explosive gas atmosphere other than mining, i.e. surface industries

Table 4. Electrical equipment for explosive gas atmosphere

3.3 Surface temperature classification

The ignition temperature, i.e. the temperature at which an ignition could occur, for example due to a hot surface of the apparatus, is dependent on the type of existing gases or vapors. This ignition temperature is influenced by several factors and is thus dependent on the stipulated testing order. Depending on the measuring system the results can thus differ in the various countries.

The maximum temperature of the exposed surface of electrical apparatus must always be lower than the ignition temperature of the dust, gas or vapor mixture, where it is to be used.

3.3.1 Group I: Electrical equipment

- With deposits of coal dust on the item of equipment ... 150 °C.
- Without deposits of coal dust on the item of equipment ... 450 °C.

3.3.2 Group II: Electrical equipment

In order to be able to mark and select electrical apparatus simply in regard to its maximum surface temperature, there are several temperature classes. The gases can be classified into the temperature classes according to their ignition temperature, whereby the maximum surface temperature of the respective class must be lower than the ignition temperature of the corresponding gases.

The standards define temperature classification as:

Temperature class (T class or rating)	One of six values of temperature allocated to electrical apparatus derived from a system of classification according to the maximum surface temperature of the apparatus
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Table 5. Definition of temperature classification

The ignition temperature of gases and vapors are in no way related to the ease of ignition by energy. Ignition temperature has to be a completely separate consideration. The temperature classification system requires that the maximum surface temperature of the apparatus is measured or assessed. The value must fall in between two temperature classes ‘T ratings’ in the following list. The lower of the two is the rating given to the apparatus.

T Class	Maximum Surface Temperature (°C)
T ₁	450
T ₂	300
T ₃	200
T ₄	135
T ₅	100
T ₆	85

Table 6. Temperature classification as defined by standards

Gases and vapors are rated in a similar way. The ignition temperature of the most easily ignitable mixture is determined and compared to the list. The higher value of temperature class is chosen as that for the mixture.

As an example, apparatus awarded T4 may be used in the presence of T4-rated gases. This means that the apparatus cannot reach a temperature above 135 °C. The T rating applied to the gas or vapor means that it is the highest it can safely encounter.

To be noted, that is the maximum ‘surface temperature’ that is of interest. Components within the apparatus may get hotter than the T rating given to the apparatus. If the flammable vapor cannot come into contact with the component at an elevated temperature because of the construction, then,

there is no need, be considered. Only the surfaces of the apparatus, which come into contact with the vapor, are of concern.

Figure 1, gives a comparison of some common gases and vapors with a temperature scale on which the T-rating values are placed.

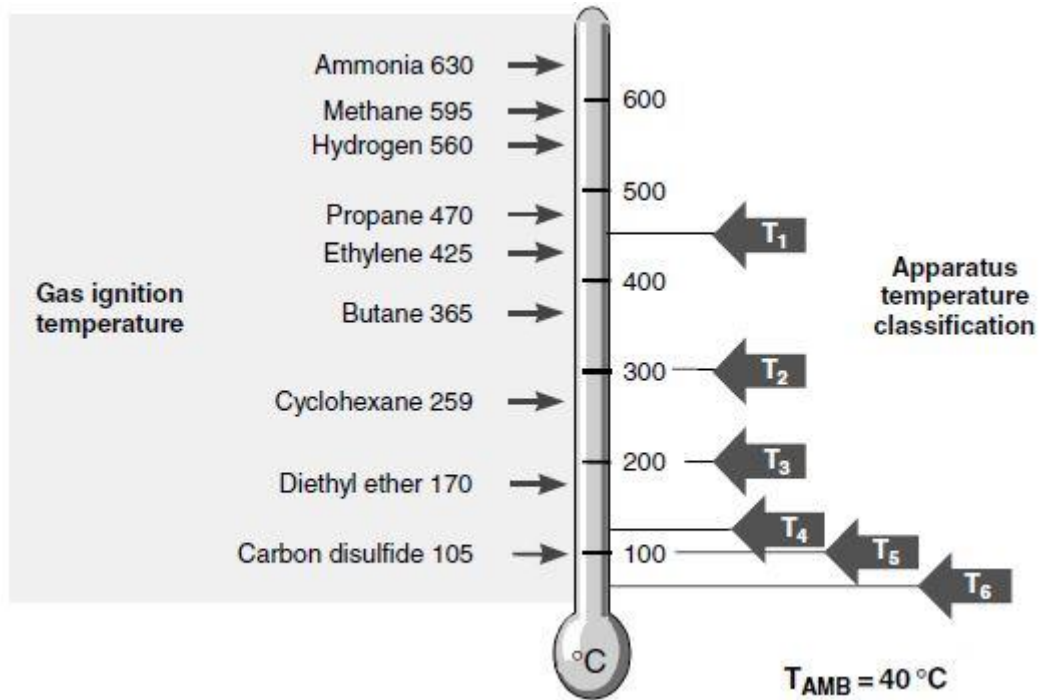


Figure 2. Temperature rating system

3.4 Concepts and techniques of explosion protection

Electrical equipment can be designed, manufactured and operated in that if they are in a hazardous area they will not contribute to causing an explosion in several ways. Today, there are three basic approaches to providing explosion protection to electrical circuits in hazardous location. They are as follows:

- Explosion confinement;
- Ignition source isolation;
- Energy-release limitation.

Understanding these techniques starts with the combustion triangle. In hazardous locations, the fuel source can be in the form of flammable vapors, liquids, gases, combustible dust or fibers, with the oxidizer being

oxygen in the surrounding air. With these two ingredients present in their most easily ignitable concentration and the introduction of sufficient electrical or thermal energy, ignition will result. Either confining or preventing this combustion from occurring can achieve a means of explosion protection.

3.4.1 Explosion confinement

A common method of providing explosion protection allows the three basic ingredients described above to coexist and potentially ignite; yet is confined within an enclosure strong enough to withstand the explosion. All joints of the enclosure are designed in such a manner that the resulting flame, sparks or hot gases are sufficiently cooled before reaching the outside atmosphere. In addition, all external surfaces must be kept below the auto ignition temperature for the specific gas the enclosure will be exposed to.

Although a popular technique, this technology does pose many drawbacks. Since the enclosures must contain an explosion, they are bulky, heavy and difficult to install. All wiring entering and exiting this enclosure must also be placed in a hardened conduit system, which requires special seals and fittings installed according to strict regulations. This entire system must be inspected frequently to ensure integrity. Loose bolts on the lid of an enclosure effectively eliminate any explosion protection for the system.

3.4.2 Ignition source isolation

The second method of explosion protection is based upon the isolation of the ignition source or energy ingredient, from the fuel/air mixture. Although there are many acceptable methods to choose from, the most popular is purging (internationally referred to as pressurization). This method reduces the concentration of the fuel/air mixture initially inside the housing to an acceptably safe level. By maintaining a high pressure inside the housing any electrical device effectively becomes isolated from the surrounding atmosphere.

Other ignition source isolation techniques include oil immersion, sealing, encapsulation, sand, powder and inert gas filling.

3.4.3 Energy release limitation

This form of explosion protection permits the energy source to exist within the fuel/air mixture but by design limits the amount of electrical and thermal energy, which could be released to levels that are incapable of causing ignition.

The most widely used forms of explosion protection, which utilize this technique, are non-sparking and IS. While both share a common foundation, they do differ greatly in many aspects. These differences deal mainly with the application of safety factors. Each does have its merits, which is why it is not uncommon to see the two techniques used together.

It should also be noted that non-sparking is not recognized outside of the United States and Canada while IS is accepted worldwide. It is generally regarded as the safest form of explosion protection. To date, no explosion can be attributed to an intrinsically safe system.

By definition, IS is an explosion-protection technique applied to electrical equipment and wiring intended for installation in hazardous locations. The technique is based upon limiting both electrical and thermal energy to levels which are incapable of igniting a hazardous mixture which is present in its most easily ignitable concentration.

Intrinsic safety reduces the risk of ignition by electrical apparatus or connecting wiring in hazardous locations. Requirements for an intrinsically safe system do not include reducing risk of explosion related to mechanical or electrostatic sparking, chemical action, radio waves or lightning strikes. Protection against such events should be employed as well.

3.5 Final considerations

The certainty of protection working correctly has partly to do with the integrity of each explosion-protection technique but is also concerned with other installation-related topics such as fault tolerance and degree of maintenance necessary. Safety in potentially explosive areas can only be guaranteed by a close and effective working relationship amongst all parties involved.

The *operator* is responsible for the safety of his equipment. It is his duty to judge where there is a risk of explosion and then divide areas into zones accordingly. He must ensure that the equipment is installed in accordance

with regulations and is tested before initial use. The equipment must be kept in a fit state by regular inspection and maintenance.

The *manufacturers* of explosion-protected apparatus are responsible for routine testing, certification and documentation, and are required to ensure that each device manufactured complies with the design tested.

The *installer* must observe the installation requirements, and select and install the electric apparatus correctly for its intended use.

4

Different Protection Concepts

4.1 Intrinsic safety Ex i

The "intrinsic safety" protection type, as opposed to other protection types, refers not only to individual items of equipment, but to the entire circuit. A circuit is described as intrinsically safe if the current and voltage are limited to such an extent that no spark or thermal effect can cause a potentially explosive atmosphere to ignite.

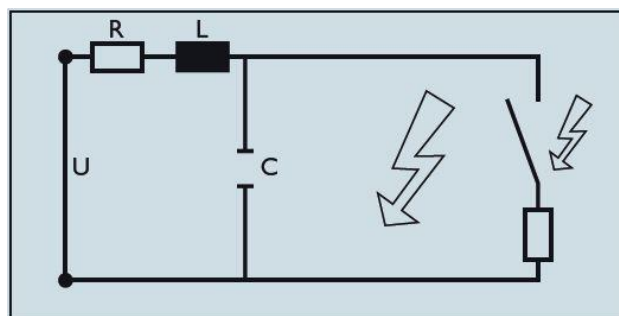


Figure 3. Basic circuit diagram

The voltage is limited in order to keep the energy of the spark below the ignition energy of the surrounding gas. The thermal effect, i.e., excessively hot surfaces, is prevented by limiting the current. This is also true of the sensors connected to the intrinsically safe circuits. Energy may be stored in the form of capacitances or inductances within the intrinsically safe circuit and this must also be taken into account when examining said circuit.

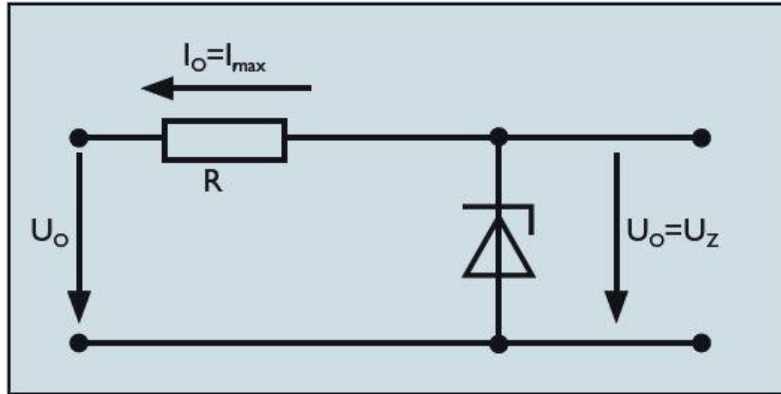


Figure 4. Basic circuit diagram for limiting voltage and current

The Zener diode becomes conductive at a defined voltage level. This limits the voltage U_o in the potentially explosive area. A resistor connected in series limits the maximum current I_o .

$$I_{max} = I_o = \frac{U_o}{R}$$

When limiting voltage and current, the following applies for the maximum power:

$$P_o = \frac{U_o^2}{4R}$$

The maximum permissible values are determined by the ignition limit curves laid down in standard EN 60079-11.

The ignition limit curves were determined using a spark tester, as described in Annex B of EN 60079-11.

The ignition limit curves contain specifications for gas groups I and II.

Group II is further subdivided into IIA, IIB, and IIC, depending on the ignition energy.

Group	Typical gas	Ignition energy/ μ J
I	Methane	280
II A	Propane	> 180
II B	Ethylene	60 ... 180
II C	Hydrogen	< 60

Table 7. Ignition energies of typical gases

4.1.1 Electrical equipment and items of associated electrical equipment

An intrinsically safe circuit consists of at least one item of electrical equipment and one item of associated equipment.

The circuits of the electrical equipment fulfill the requirements of intrinsic safety. Electrical equipment may only be connected to circuits without intrinsic safety via associated equipment. Associated equipment has both intrinsically safe circuits and circuits without intrinsic safety. The circuits are isolated using Zener barriers or electrical isolators.

Intrinsically safe electrical equipment and intrinsically safe parts of associated equipment are classed according to EN 60079-11 in safety levels "ia", "ib", and "ic".

Safety level	Fault monitoring	Permissible zones
ia	Under normal operating conditions, not able to cause ignition if any combination of two faults occurs.	0,1,2
ib	Under normal operating conditions, not able to cause ignition if one fault occurs.	1,2
ic	Under normal operating conditions, device is not able to cause ignition.	2

Table 8. Safety level according to EN 60079-11

Safety level "ia", "ib" or "ic" defines whether protection is maintained with two or one faults in the protective circuit, or whether no protection is provided in the event of a fault.

Intrinsic safety is based on monitoring faults in order to rule out the danger of explosion. This does not, however, provide any conclusions as to operational reliability. This means that a total functional failure of the item of equipment can be permissible from the point of view of explosion protection.

Electrical equipment can be used right up to Zone 0 in accordance with the safety level. Associated equipment is installed in the safe area. Only the intrinsically safe circuits are routed into the potentially explosive area, according to the safety level.

Associated equipment can always be designed in a different protection type in order for it to be installed in Zone 2 or maybe even in Zone 1.

4.1.2 Associated equipment with/without electrical isolation

For intrinsically safe circuits in Zone 0, standard EN 60079-14, Section 12.3 recommends that electrical isolation should be preferred, along with the "ia" safety level.

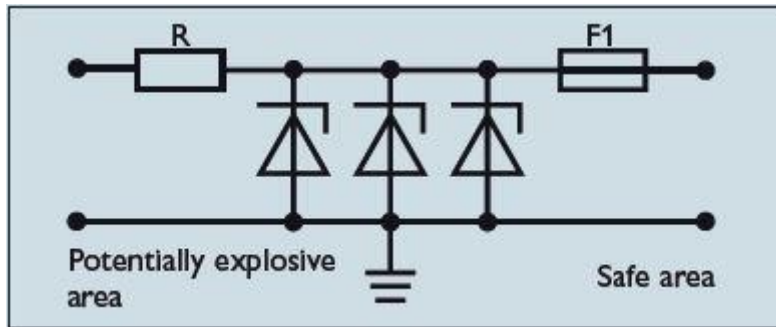


Figure 5. Circuit without electrical isolation: Zener barrier

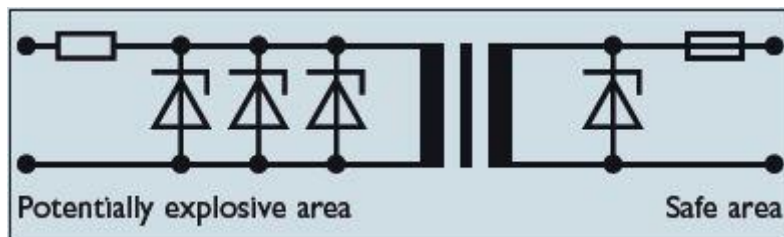


Figure 6. Circuit with electrical isolation: Isolator

4.1.3 Simple electrical equipment

Simple electrical equipment does not require approval; however, it must be assigned to a temperature class and conform with any other applicable requirements of EN 60 079-11.

The maximum temperature can be calculated from power P_o of the associated equipment and the temperature class can then be determined.

The characteristics of the power storage device must be specified precisely and must be taken into account when determining the overall safety of the system.


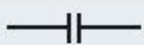





Passive components	Power storage device	Power sources*
 Pt100	 Capacitor	 Thermocouple
 Switch	 Coil	 Photo cells
 Distributor boxes		* Requirement U ≤ 1.5 V I ≤ 100 mA P ≤ 25 mW

Figure 7. Overview of simple electrical equipment (EN 60079-11)

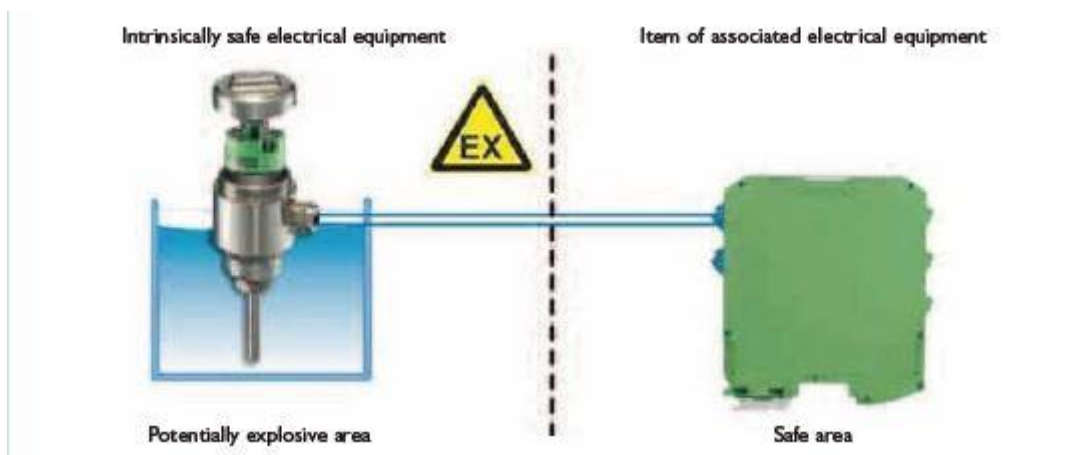


Figure 8. Interconnection of electrical equipment in the "intrinsic safety" protection type

4.2 Protection type "n"

Protection type "n" can be described as an improved industrial quality that is designed for normal operation. A fault scenario examination as is performed for the "intrinsic safety" protection type, for example, is not carried out.

This can only be applied for Equipment group II and the use of electrical equipment in Zone 2. The manufacturer specifies the technical data for normal operation. In protection type "n", five different versions are distinguished, which can be derived in part from the well-known protection types "increased safety", "intrinsic safety", "flameproof enclosure", "pressurization", and "molded encapsulation".

This protection type was developed based on the US "non-incendive" protection type and was introduced in Europe as a standard in 1999. Here it is further divided into the subgroups nA, nC, nR, nL, and nP.

Abbreviation	Meaning	Comparable to ...	Method	Subdivisions of Group II
A	Non-sparking	Ex e	Occurrence of arcs, sparks or hot surfaces is minimized	As of EN 60079-0:2009, subdivided into IIA, IIB, IIC
C	Sparking items of equipment	To some extent, Ex d and Ex m	Enclosed switching device, non-incendive components, hermetically sealed, sealed or encapsulated installations	IIA, IIB, IIC
R	Restricted breathing housing	---	Ingress of explosive gases is limited	As of EN 60079-0:2009, subdivided into IIA, IIB, IIC
L *	Energy limited	Ex i	Energy limitation so that neither sparks nor thermal effects cause an ignition	IIA, IIB, IIC
P	Simplified pressurization	Ex p	Ingress of explosive gases is prevented by overpressure, monitoring without disconnection	As of EN 60079-0:2009, subdivided into IIA, IIB, IIC

* Different in North America and Europe

Table 9. Subdivision of protection type "n" in Europe

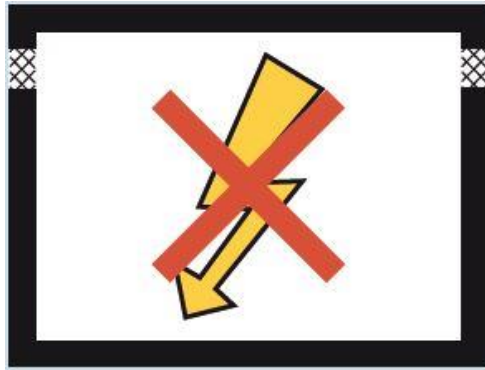
Subdivision of protection type "n" in North America	
Designation according to NEC	Meaning
Energy limited "nC" *	Energy limited
Hermetically sealed "nC"	Hermetically sealed
Non-incendive "nC"	Non-incendive items of equipment
Non-sparking "nA"	Non-sparking items of equipment
Restricted breathing "nR"	Restricted breathing
Sealed device "nC"	Sealed items of equipment
Simplified pressurization "nP" **	Simple pressurization

* Different in North America and Europe

** Designated as type X, Y, and Z in the USA

Table 10. Subdivision of protection type "n" in North America

4.3 Increased safety Ex e



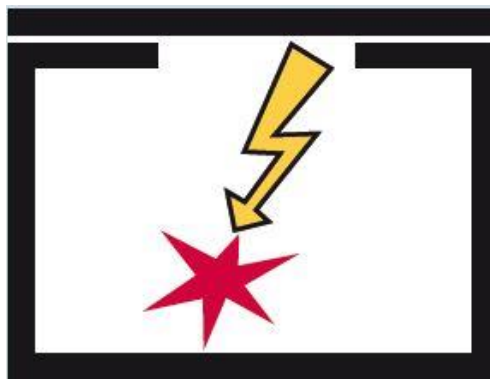
In the "increased safety" protection type, voltages up to 11 kV can be brought into the potentially explosive area. Increased safety is especially suitable for supplying motors, lamps, and transformers.

The protection principle is based on constructional measures.

Air and creepage distances are determined for the live parts, divided into voltage levels. This prevents electrical sparks.

Limiting the surface temperature ensures that the potentially explosive atmosphere cannot be ignited at any place, even inside the housing, during operation. The housing does not prevent gas from entering.

4.4 Flameproof enclosure Ex d



In the "flameproof enclosure" protection type, an explosion is prevented from spreading by the housing design. An explosion that occurs inside is not able to ignite the potentially explosive atmosphere surrounding the housing.

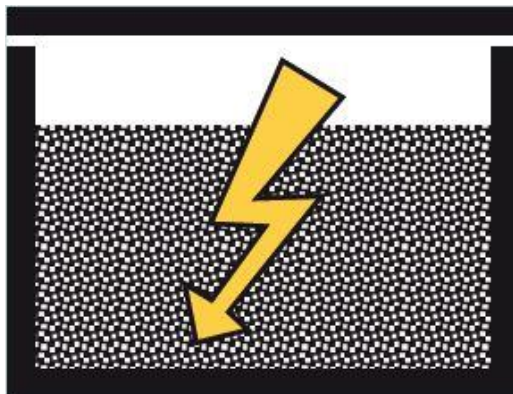
This leads to very rugged housings.

The housings have covers and insertion points, for example, for cables and lines.

The maximum permitted gap that is present is dimensioned in such a way that it prevents the explosion from being carried over from inside the housing to the surrounding potentially explosive atmosphere.

In the case of cable and line entries in the Ex d protection type, it is not permitted to grease the thread or remove rust with a wire brush. Doing this could change the gap, thus destroying the protection principle. The manufacturer's specifications must be observed.

4.5 Molded, sand or oil encapsulation Ex m, Ex q, Ex o



The principle of the "molded encapsulation", "sand encapsulation", and "oil encapsulation" protection types is to surround possible sources of ignition in an item of electrical equipment with the medium of a molding compound, sand or oil. This prevents the potentially explosive atmosphere from igniting.

Voltages from 10...11 kV can also be used in these protection types.

4.6 Pressurization Ex p



The "pressurization" protection type describes methods that use overpressure to prevent a potentially explosive atmosphere from entering into the housing or the control room.

The ambient pressure around the housing is always lower than inside.

Three forms of pressurization are possible (see table 9). In the case of static overpressure, the housing must be hermetically sealed. No loss of pressure occurs. More common, however, are methods in which the overpressure is maintained by compensating the leakage losses or by continuous purging. The overpressure is usually created by simple compressed air.

The Ex p protection type requires a monitoring unit that reliably switches off the electrical equipment inside the housing as soon as sufficient overpressure is no longer present. The monitoring unit must be designed in a different protection type, so that it can also be operated without overpressure.

Items of equipment can be operated inside without taking explosion protection into account.

The surface temperature of the items of equipment must not ignite the penetrating potentially explosive atmosphere once the overpressure has dropped.

If operational conditions dictate that a device or component inside the housing must not be switched off, it must be protected against explosion via a different protection type.

Pressurization	Static	Compensation of the leakage losses	Continuous purging
Compressed air	Without correction	Compensation of the leakage losses	Continuous correction
Operating states	---	Pre-purging phase: The housing is purged and any potentially explosive atmosphere that is present is removed from the housing. Operating phase: The overpressure in the housing is monitored. If it decreases, the electrical equipment inside the housing is switched off.	

Table 11. Possibilities of pressurization

5

Safe Working Practice

Having a project designed and installed as per the regulations it is of utmost importance to give adequate attention to the adoption of safe working methods and practices that will ensure:

MISHAP PREVENTION AND LOSS PREVENTION OF MEN AND MATERIAL

Most of who works with electricity take risks. Mishaps or injuries usually result from an unclear understanding of a risk or danger.

It is important to look at some of the more obvious practices that any electrical technician is supposed to follow in terms of:

- Safety
- Looking out for danger signals
- Inspection and maintenance requirements
- Maintenance and safe practices

- Safe methods of insulation testing and requirements for hazardous area
- Safe methods of earth integrity checking and the specific requirements for a hazardous area
- Safe practices after fire and electrical shock.

5.1 Safety observations

Working safely is the most important thing you can do. Of course, there are more precautions, but these are some you should definitely care about. The keyword here is *think*.

- Never work alone;
- Never receive an intentional shock (e.g. by testing);
- Only work on, operate or adjust equipment if you are authorized;
- Do not work on energized equipment unless absolutely necessary;
- Keep loose tools, metal parts and liquids from the electrical equipment. Never use steel wool or emery cloth on electric and electronic circuits;
- Never attempt to repair energized circuits except in an emergency;
- As a general rule, never measure voltages in excess of 300 V while holding the meter wire or probe;
- Use only one hand when operating circuit breakers or switches;
- Use proper tag-out procedures for regular and preventive maintenance;
- Be cautious when working in voids or unvented spaces;
- Beware of the dangers of working aloft. Never attempt to stop a rotating antenna manually;
- Keep protective closures, fuse panels and circuit breaker boxes closed unless you are actually working on them;
- Never bypass an interlock unless you are authorized to do so by the authorized persons, and then properly tag the bypass.

Warning signs

They have been placed for your protection. To disregard them is to invite personal injury as well as possible damage to equipment. Switches and

receptacles with a temporary warning tag, indicating work is being performed, are not to be touched.

Working near electrical equipment

When work must be performed in the immediate vicinity of electrical equipment, check with the technician responsible for the maintenance of the equipment so you can avoid any potential hazard of which you may not be immediately aware.

Authorized personnel only

Because of the danger of fire, damage to equipment and injury to personnel, only authorized persons shall do maintenance work on electrical equipment. Keep your hands off all equipment, which you have not been specifically authorized to handle. Particularly stay clear of electrical equipment opened for inspection, testing or servicing.

Circuit breakers and fuses

Covers for all fuse boxes, junction boxes, switch boxes and wiring accessories should be kept closed. Any cover, which is not closed or is missing, should be reported to the technician responsible for its maintenance. Failure to do so may result in injury to personnel or damage to equipment in the event accidental contact is made with exposed live circuits.

5.2 Need for inspection and maintenance

‘Loss prevention’ is one of the main objectives of any ongoing enterprise, it is needless to emphasize that this can be only achieved if all the apparatus, equipment and systems for hazardous area are designed, selected and installed with great care. The equipment must also be maintained as close as possible to the state it was when it was new.

Electrical installations, which comply with standards and regulations, or with other statutory documents dealing with the same subject, possess features specially designed to render them suitable for operation in hazardous areas. It is essential for reasons of safety in those areas that throughout the life of

such installations the integrity of those special features is preserved. They therefore require systematic inspection and if necessary, maintenance both initially and at regular periodic intervals thereafter.

The above makes it imperative that a formal and exhaustive documentation procedure should be put in place. This should also cover the requisite procedures for inspection, testing and certification wherever necessary for the following:

- Commissioning and test verification
- Operation
- Storage of flammable material
- Maintenance schedule
- Authorized modifications
- Overhaul and repair.

It should be noted that the required certificate/documentation needs to be issued for the maintenance schedule and authorized modifications, and these should be included in a hazardous area verification dossier. Normal overhaul and other activities need also to be suitably documented.

The facility in charge shall nominate a person (or persons) having the appropriate knowledge and experience of hazardous area installations to be responsible for establishing and implementing a system of inspection and maintenance, which shall keep the plant operating safely.

6

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