# Explosion risk assessment for already installed equipment

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**Abstract.** The equipment of installations for the processing, transport or storage of flammable substances which may generate an explosive atmosphere, in or around them, must be assessed in terms of the risk of explosions, both when they are put into operation or when the installation is modified and periodically for verify that the initial level of protection is maintained. The purpose of the assessment is to establish appropriate protective measures to prevent sources of ignition that could initiate explosive atmospheres. Explosion risk assessment is an obligation of the employer who must draw up an explosion protection document, as regulated in GD 1058/2006 transposing European Directive 1999/92/EC. The explosion risk assessment process focuses primarily on the formation of explosive atmospheres and then on the presence and activation of ignition sources. The principle of explosion protection is to reduce the probability of an ignition source occurring at the same time as the explosive atmosphere, to a minimum acceptable level according to the applicable norms and standards. The paper presents some aspects regarding the evaluation of the risk of explosions to already installed equipment, assembled in an installation, depending on the specific conditions.

## 1 Introduction

With the development of technical-scientific, new types of equipment / installations have appeared with increased reliability and safety, being available much improved components, electrical controls and extremely sophisticated safety devices as well as more resistant and durable materials. New technologies create new challenges in assessing the risks of explosion when they are installed in environments with a potentially explosive atmosphere.

The purpose of the explosion risk assessment is to set of appropriate measures to reduce it, in accordance with the requirements of the norms and standards. We can say that, through abiding by the norms, the presumption of providing an acceptable risk level is ensured.

There is no generally valid method for assessing the risk of explosions, but there are a number of norms / standards that give essential safety and health requirements, respective

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that specify requirements for the constructional features of equipment and components that may be an individual item or form an assembly, to enable them to be used in atmosphere potential explosive, such as the series of standards SR EN 60079 [1], SR EN 80079 [2] or standards with basic concepts and methodology for explosion prevention and protection - SR EN 1127-1[3] and SR EN 1127-1[4]. These standards have been developed to help designers, manufacturers, users of equipment and components that may be an individual item or form an assembly, and other interested bodies to interpret the essential security requirements in order to comply with European legislation and ATEx Directives respectively 2014/34/EU [ 5] and 1999/92/EC [6]. These standards are only the starting point for the minimum requirements.

If we refer to an installation, the risk analysis focuses on its design, construction, maintenance and supervision from a technical and organizational point of view. Even if a new installation has been evaluated during commissioning and complies with the explosion protection requirements, it is necessary, at all times, to apply adequate maintenance measures which are carried out according to a well-established schedule and with competent persons for these activities.

In the case of assessing the exploration risk of the installations already put into operation, several situations can be encountered:
- the installation has been placed on the market as an assembly by the manufacturer, with an evaluation document in accordance with the ATEx Directive and no further evaluation must be made by the user (employer) [7,8 ];
- the installation was made by the user by assembling the components at his own responsibility and in this case he must make a risk assessment when commissioning [9].

Also, the employer must evaluate the installation regarding the risk of initiation whenever the installation is modified in order to upgrade it or if original spare parts that were considered at the initial assessment (commissioning) are not available on the market.

A common situation in old installations is when an initial evaluation is not available and then an evaluation of the installation must be made as if it were new.

## 2 Analysis of explosion risk assessment methods

An explosion occurs if a fuel is present mixed with air (so enough oxygen) within the explosion limits, together with a source of ignition.

In the event of an explosion, workers are exposed to the risks of uncontrolled flames and the effects of pressure in the form of thermal radiation, flames, pressure waves and projected waste and from harmful products as well as the consumption of respirable oxygen from the surrounding air. Risk in the explosion safety consists of two elements: probability of occurrence the harm and the severity of the possible harm. Risk = Likehood x Severity.

The severity or consequence of an explosion can often be adequately characterized however the probability of its occurrence is usually very difficult to quantify. The analysis of the consequences (the magnitude of the foreseeable consequences) is not very important because it is known that the explosions always involve considerable damages, starting from important material damages and to human injurys that could lead to death.

Likelihood of an explosion is determined of the likelihood of an explosive atmosphere occurrence, together with the occurrence of an efficient ignition source.

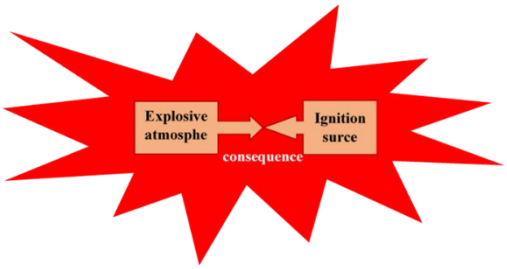


**Fig. 1** Explosion risk

When flammable substances are involved that can generate an explosive atmosphere, we cannot speak of zero risk of explosions but only of a minimum accepted risk that is given in the legislation in force (ATEx Directives and applicable standards) in the form of minimum explosion requirements.

Explosion prevention measures at installations used in potentially explosive atmospheres to ensure a minimum level of risk are based on the principle that: the higher the probability or frequency of an explosive atmosphere, the higher the level protection provided by equipment / installations for the prevention of efficient ignition sources (minimum probability of arising the ignition source when an explosive atmosphere occurs)

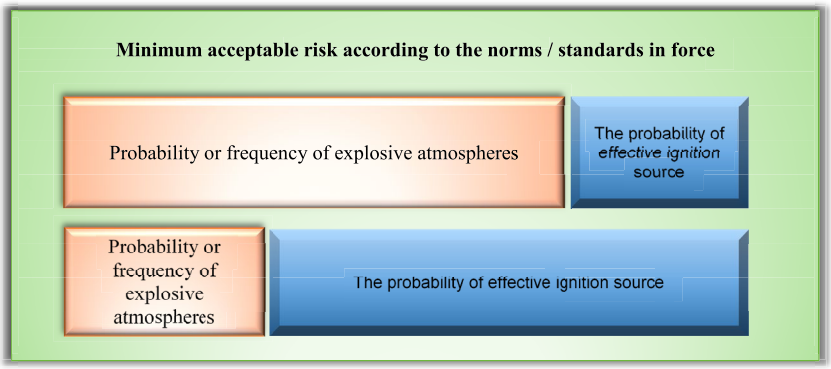


**Fig. 2** Minimum acceptable ignition risk

## 3 Explosion risk assessment of installation

According to the legislation in force, employers are responsible for the safety and health of workers and in this regard they must take appropriate measures to prevent explosions or, as appropriate, to limit the effects of possible explosions. For this they have to make an explosion risk assessment which will be an important chapter in DPEX that the employer has to prepare, according to art. 10 of GD 1058/2006 (Directive 1999/92 / EC) [9].

Whenever possible, the employer should prevent explosive atmospheres. It follows that the first step in assessing the risk of explosion is to determine whether an explosive atmosphere may occur under the given circumstances and then, in step 2, it must be determined whether it can be ignited or not .

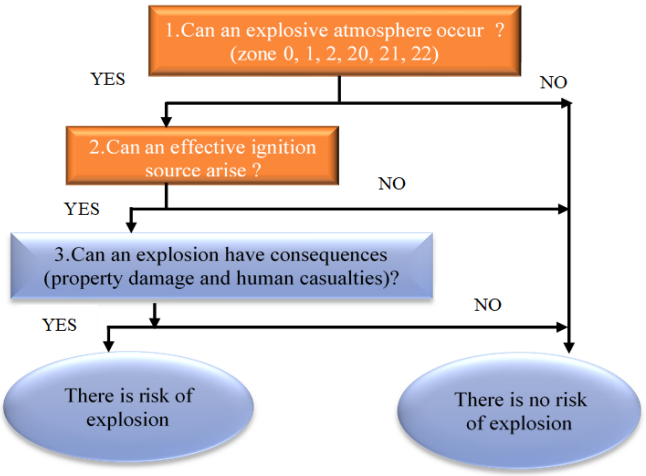


**Fig 3.** Assessement of explosin risk

Steps 1 and 2 represent ignition risk assessment. The process of assessing the risk of initiation cannot be generalized, it is specific to each case. The specific considerations are the probability and duration of the occurrence of the dangerous explosive atmosphere, the probability that the ignition sources will be present and become efficient and active by analyzing the installations, the substances used, the processes and their interactions [10].

If we refer only to installations, we must think of the ignition sources that it can generate in normal operation, of foreseeable failures or rare failures. Ignition sources are well defined in SR EN 1127-1 and SR EN 1127-2. Thirteen types of ignition sources are distinguished: hot surfaces, hot flames and gases, mechanically generated sparks, stray electric cleaners, cathodic corrosion protection, static electricity, lightning, electromagnetic fields in the frequency range between 9 kHz and 300 GHz, electromagnetic radiation frequency range between 300 GHz and $3x10^6$ GHz or wavelengths from 1000 µm to 0.1 µm (optical spectrum), ionizing radiation Ultrasound, adiabatic compression, shock waves, gas leaks, chemical reactions.

The evaluation procedure of an installation, new or existing, must be based on the following functional statutes:

- normal operation, including maintenance
- commissioning and decommissioning
- malfunctions, foreseeable fault conditions
- misuse that can be rationally predicted

The method of assessing ignition risk installations must be systemic, performed in a structured manner, on an objective and logical basis. An analysis is made of existing sources of hazardous explosive atmospheres and of efficient sources of ignition that may occur at the same time [.

The principles and guidelines for risk management defined in the ISO SR 31000:2010 together with methodology from SR EN 15198:2008 can be applied to *ignition risk assessment* [11].

The minimum level of risk accepted by the rules corresponds to the minimum probability that the ignition source will appear in the same place and at the same time as the explosive atmosphere. The application of this principle is based on the classification of the hazardous area into zones according to the frequency and duration of the explosive atmosphere and the classification of the equipment into categories according to the level of protection provided, and the acceptance criterion is given in the table 1.

**Table 1.** Level of protection required, in function of the explosive atmosphere

| | CATEGORY OF EQUIPMENT | ATMOSPHERE | Level of protection | PERFORMANCE OF PROTECTION | CONDITION OF OPERATION |
|---|---|---|---|---|---|
| **EQUIPMENT GROUP I (MINES)** | M 1 | Methane, dust | Very high | 2 independent protection methods, or safe with 2 faults | Equipment remains energised and functioning |
| | M 2 | Methane, dust | High | Suitable for normal operation and severe operating conditions | Equipment is de-energised |
| **EQUIPMENT GROUP II (SURFACE)** | 1 | Gas, vapour, mist dust | Very high | 2 independent protection methods or safe with 2 faults | Equipment remain energised and functioning in zone 0, 1, 2 (G) and/or 20, 21, 22 (D) |
| | 2 | Gas, vapour, mist dust | High | Suitable for normal operation and frequently occuring disturbances, or safe with 1 fault | Equipment remain energised and functioning in zone 1, 2 (G) and/or 21, 22 (D) |
| | 3 | Gas, vapour, mist dust | Normal | Suitable for normal operation | Equipment remain energised and functioning in zone 2 (G) and/or 22 (D) |

Most of the electrical and non-electical equipment from the installation component is certified as an individual item of equipment, e.g. the motor, switchgear etc., and meets its own marking requirements. This certification, however, does not deal with the interconnection of these items of equipment by cables or the machine electrical power system as an entity. The equipment and components, including their interconnections, should be assessed, from an ignition point of view, by the manufacturer or user.

When the installation is manufactured by a manufacturer as "Equipment assemblies" as specified in the technical specification IEC TS 60079-46 (a pre-manufactured combination of Ex Equipment, together with other parts as necessary, that are electrically or mechanically interconnected that are pre-assembled prior to being placed into service at the end-user site, and that can be disassembled and then re-assembled at the end-user site) , the ignition risk assessment is part of the conformity of the product with the essential health

and safety requirements (EHSRs) of the Directive ATEX 2014/34/UE, in order to place the products on the market.

Issue of IEC TS 60079-46 Explosive atmospheres - Part 46: Equipment assemblies is a good opportunity for inspiration to clarify objectives and evaluation methods.

This document concentrates on the use of IEC 60079-14 for the interconnection of electrical units forming part of the overall assembly, but did, for the first time, acknowledge, internationally, the commercial need to provide single documentation covering an assembly. Because the scope of this document was limited, the subject was immediately referred to the standards committee IEC TC31 who took it on board to produce a more comprehensive document with a wider scope.

IEC TS 60079-46 was published a year ago in August 2017. (A TS is subject to review within three years to determine if it should be cancelled, amended, or immediately transformed to a full international standard.) Although a TS rather than a standard, IECEx adopted it immediately for certification purposes. [12]

This standard together with the series of standards SR EN 60079, SR EN 80079 on the types of protection, including SR EN 60079-14 [13], for the requirements for mounting equipment in ex areas and SR EN 15198, SR EN 15233 [14] to the evaluation methods constitutes the minimum necessary information in order to be able to start an initiation risk assessment for an installation.

When the installation is made by assembling the component parts by the user (employer), he has to choose the equipment corresponding to their dangerous areas. Following, the installation as a whole shall be assessed with regard to possible ignition sources. All electrical and non-electrical equipment, the associated connected devices have to be taken into consideration.

Each ignition source according to EN 1127-1 or EN 1127-2 must be analysed.

Sometimes the level of protection required to prevent the efficient source of initiation of the installation is achieved with monitoring systems of safety parameters, with regulation, control and safety devices (hereinafter referred to as process control technologies - PCE process control engineering).

**Table 2.** Use of PCE devices to reduce the probability of effective ignition

| **Hazardous place** | **Occurrence of ignition sources** | **Requirements for PCE devices** |
|---|---|---|
| Zone 2 or 22 | Operationally necessary | Suitable single device for avoiding ignition sources |
| | Unlikely in normal operation | none |
| Zone 1 or 21 | Operationally necessary | Two suitable devices for avoiding ignition sources* |
| | Unlikely in normal operation | Suitable single device for avoiding ignition sources |
| | Unlikely in normal operation or in the event of malfunction | none |
| Zone 0 or 20 | Unlikely in normal operation | Two suitable devices for avoiding ignition sources |
| | Unlikely in normal operation or in the event of malfunction | Suitable single device for avoiding ignition sources* |
| | Unlikely in normal operation, in the event of malfunction or in the event of rare malfunctions | none |

* or an equivalent device tested in accordance with Directive 2014/34/EC

In general, PCE devices can be used to prevent sources of ignition, but they are also used to prevent dangerous explosive atmospheres or to reduce the harmful effects of an explosion.

In some cases, it may be useful to combine PCE devices to prevent ignition sources with PCE devices to prevent hazardous explosive atmospheres.

Sometimes it may be necessary to de-energize the equipment containing ignition sources when an explosive concentration of the flammable substance is present.

The reliability of PCE devices together with the technical and organizational measures taken must ensure that the danger of an explosion is limited to an acceptable level, in all operating conditions. The degree of reliability required by PCE devices depends on the explosion risk assessment. The reliability of the safety function of PCE devices and their components is ensured by avoiding defects and controlling defects (with regard to all operating conditions and planned service and / or maintenance measures).

It is recognized that systems with proven reliability according to functional safety standards (IEC 61508, IEC 61511 or ISO 13849-1) are available and may be used to demonstrate that the required reliability has been achieved but the use of such systems is not a requirement of this standard [15].

If is not possible to avoid explosive atmospheres and sources of ignition to the required level, protective systems should be used to limit the effects of explosion.

The end user should always evaluate each individual part of the installation for potential ignition sources and monitoring needs, as performance can vary significantly from one installation to another, may have its own unique behavior.

Assessing the risk of initiation is not easy, it requires experience and professionalism. For equipment and components, the identification of potential ignition sources is the most important part of the ignition risk assessment [16]. For identification of all possible ignition hazards it is important to proceed systematically and do it without any assessment aspects to avoid restrictions in thinking. For the analysis of the possible ignition hazards, all utilizable information sources should be used (discussions with experts from test houses, universities, users, other manufactures etc.) and all accessible examples should be examined to perceive analogy [13]. The use of standards is only the starting point for compliance with the minimum requirements.

In order to meet these minimum requirements or to exceed them in order to ensure a higher level of security, complex hazard monitoring systems have been developed.

In this regard, employers should consider each installation and determine the possibilities for hazard monitoring, both in the domain of minimum ATEx requirements and outside them. Of course, the budgetary constraints of an organization in implementing a hazard monitoring system better than the minimum required by the rules, will always be a priority and management must assess the risk and cost of options acceptable to the company. However, it appears that the benefits of hazard monitoring versus the fairly reasonable cost of hazard monitoring equipment are a good assurance and a solid investment in reducing the risks of loss of life, property and product.

## 4 Conclusions

The assessment of installations on the risk of the ignition of explosive atmospheres is the responsibility of the employer, in accordance with GD 1058/2006 transposing Directive 1999/92 / EC.

If the installation has been placed on the market as an assembly by the manufacturer, who has assessed the assembly for compliance with the requirements of the ATEx Directive, no further evaluation is required, but if the installation was built by the user /

employer by assembling of components in situ it must to make an initial evaluation, at commissioning, as a manufacturer.

The ignition risk assessment is performed to verify that the probability of an ignition source occurring at the same time as the explosive atmosphere occurs is minimal according to the norms and standards in force.

Initiation risk assessment is not easy, it requires experience and professionalism specially to identify potential ignition sources. The evaluation process cannot be generalized, it is specific to each case.

The methods applicable for the assessment must consider the sensitivity of the explosive atmosphere (characteristics of the substances) and the probability of its occurrence together with the probability of ignition of the sources in relation to the requirements of applicable ATEx standards and norms.

## References

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