Explosion risk assessment - an important chapter of the explosion protection document

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Abstract. In order to improve the safety and health protection of workers who may be exposed to a potential risk due to explosive atmospheres, in every industrial area where such atmospheres may occur, the employer shall ensure the development and updating of a document called Explosion Protection Document. The main chapter of this document is the Explosion Risk Assessment.

Risk assessment is a complex process that involves identifying the risk, analyzing the risk and estimating the risk, the main purpose of assessing the level of risk being to establish the necessary protection measures to reduce it to acceptable levels.

This paper identifies the factors that may influence the level of risk of explosions in the workplace in order to establish the protection measures required to reduce the risk to acceptable levels. Explosion risk assessment must be performed by competent persons with knowledge of technical, electrical and mechanical engineering and who understand the general principles of explosion protection.

1 Introduction

As explosions can cause human losses and immeasurable property damage, the assessment of the risk of explosion and the establishment of appropriate precautionary measures to reduce it to acceptable levels in accordance with the rules and standards in force are of particular importance for the safety and health of humans and property.

Romania has adopted European legislation on explosion protection, such as the ATEx Directive 2014/34/EU [1] of the European Parliament and of the Council of 16 December 1999 transposed in Government Decision no. 1058 of 2006 on the minimum requirements for improving the safety and health protection of workers who may be exposed to a potential

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risk due to explosive atmospheres. This directive provides for the development and updating of the explosion protection document by the employer.

The Explosion Protection Document (DPEx) is prepared prior to the commencement of the activity and is intended to provide an overview of the results of the risk assessment and subsequent technical and organizational protection measures for an installation and its working environment.

This document must demonstrate that:

• Explosion hazards have been determined and evaluated

• Appropriate measures shall be taken to achieve the objectives of the ATEx Directive 2014/34/ EU [1]

• What places have been classified by area

• What are the places where the minimum requirements for improving the protection of the health and safety of workers in potential danger in explosive atmospheres apply?

• The workplace and work equipment are designed, built and maintained in accordance with labor protection regulations.

• Measures have been taken for the safe use of work equipment in accordance with the provisions of Council Directive 89/655 / EEC.

The structure of DPEx is not a mandatory one, but as it is observed in the specialized literature, it must contain at least the following chapters:

- A description of the job entity for which the DPEx is prepared
- Identify substances that can generate an explosive atmosphere.
- Explosion risk assessment.
- Establishing the protection measures that must be taken after the risk assessment.
- How to implement the established measures
- Coordination of explosion protection measures.

The most important part of DPEx is explosion risk assessment because the purpose of developing DPEx is to establish explosion protection measures to be taken based on the outcome of the risk assessment.

2 Explosion risk assessment

Requirements for explosion prevention and protection in potentially explosive atmospheres are generally addressed in international norms and standards. If we refer to the European level, we have in mind the two ATEX Directives: Directive 2014/34 /EU (GD 245/2016) and Directive 1999/92 / EC (GD 1058/2006) together with the applicable standards, of which the basic ones are the series SR EN 1127 -1 [2], SR EN 60079- 0 [3], SR EN 80079-36 [4] s.a. These guidelines and standards set out the requirements for the placing on the market of equipment and for the use to be taken into account in the risk assessment. The specialty literature presents a series of evaluation models applied by various bodies notified [5], [6], [7].The issue was also the subject of a European project: The RASE Project- Explosive Atmosphere: Risk Assessment of Unit Operations and Equipment, EU Project No: SMT4-CT97-2169 [8]

In this context, based on long experience, NRDI INSEMEX has developed tools to help companies assess explosion risks.

The developed methodology starts from the risk management process, according to SR ISO 31000: 2010 [9], customized on risk management for equipment and components intended for use in potentially explosive atmospheres treated in SR EN 15198 [10], taking into account the fundamental concepts and methodology of prevention and protection explosions from SR EN 1127-1 [2] and directions from The RASE Project- Explosive Atmosphere: Risk Assessment of Unit Operations and Equipment, EU Project No: SMT4-CT97-2169 [8]

The risk management process, according to SR ISO 31000:2018 [9], is presented in figure no. 1:

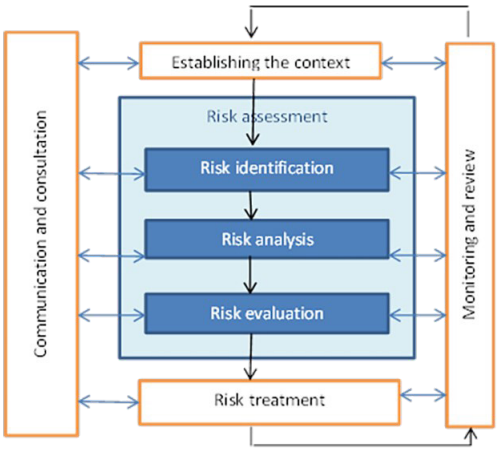

Fig 1. The risk management process

The basic principles of explosion prevention and protection are in order of importance:

a) prevention of the formation of explosive atmospheres or

b) avoid ignition of explosive atmospheres where their formation cannot be prevented and

c) limiting the harmful effects of an explosion in order to ensure the health and safety of workers.

A logical scheme of the explosion risk assessment process in the case of installations in potentially explosive atmospheres which aims to verify the achievement of the required level of security and can be presented as follows:

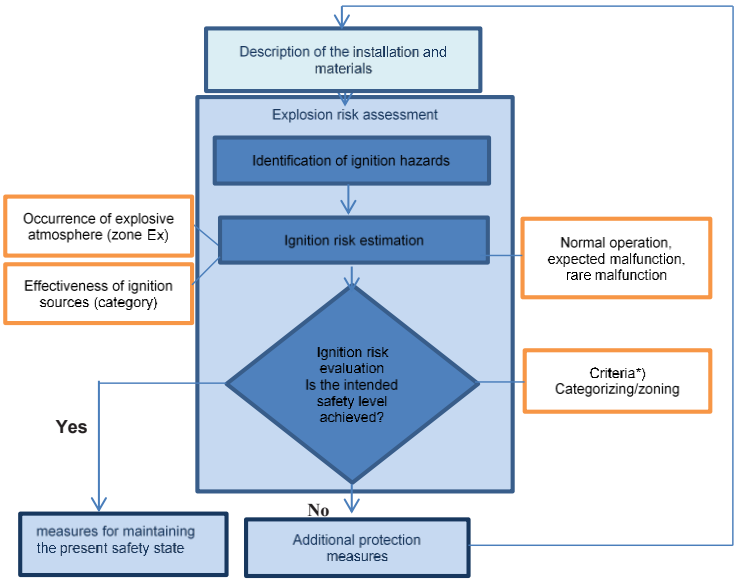

Fig. 2. Evaluation of the risk of explosion in installations from potentially explosive atmospheres

The danger of explosion is related to the materials and substances processed, used or released by the equipment and the risk of ignition is related to equipment or installations that can generate sources of ignition, therefore a good part of the risk assessment of explosions refers to the conformity assessment of equipment. installations with explosion prevention and protection requirements.

The risk of explosion is the probability of an explosive atmosphere occurring at the same time as the occurrence of an efficient ignition source and its effects.

The assessment of specific hazards in explosive atmospheres is a complex process that must take into account at least:

- Probability of occurrence and persistence of explosive atmospheres
- The probability of the presence and activation of ignition sources, including electrostatic discharges.
- Installations, substances used, processes and their possible interactions.
- Dimensions of anticipated effects.

The risk assessment process focuses primarily on the formation of explosive atmospheres and then only on the presence and activation of ignition sources, the examination of the consequences being of secondary importance because it is known that explosions always cause considerable damage to both material and damage. which can cause death.

Every work and production process, as well as every condition of operation of a plant and every change of these conditions must be evaluated.

3 The stages of the risk assessment process

Explosion risk assessment: risk identification, risk analysis and risk estimation.

3.1 Risk identification

The risk of explosion may occur in all activities involving gases, vapors, flammable mists or combustible dusts which, when mixed with air, may form an explosive atmosphere.

An important element in assessing the risk of explosions in workplaces where explosive atmospheres may occur is the personal protective equipment and equipment that must be designed, manufactured, installed and maintained so that it cannot generate ignition sources. Explosion prevention and protection requirements are regulated in specific norms and standards, and an important part of the explosion risk assessment is the assessment of the conformity of the equipment and installations with the respective requirements.

Avoidance or reduction of explosive atmospheres can be achieved either by changing the concentration of the flammable substance to a value that is outside the explosion range, or to the oxygen concentration, to a value below the limit oxygen concentration.

Practice has shown that in most cases where flammable materials are used, an explosive atmosphere or the equipment used to generate a source of ignition is very likely to occur, so the following principle must be observed to prevent explosions: the probability that a source of ignition will occur. at the same time with an explosive atmosphere to be minimal.

For the application of this principle, Ex non-mining hazardous areas are classified into zones according to the probability and duration of the explosive atmosphere, and the equipment is divided into categories according to the level of protection provided.

First of all, in practice, the areas where explosive atmospheres can occur and the probability of their presence are established by applying a "Zoning" method and then the possible sources of ignition must be identified taking into account the normal operation but also any foreseeable or rare faults. Each ignition source is analyzed according to EN 1127-1: 2019 [2]

Table 1. Classification of hazardous areas into zones

ZONE	The presence of the explosive atmosphere
2	Infrequent or only for a short period of time
1	Probably appear
0	Continuously, for long periods, or frequently
Directiva 1999/92/EC (HG 1058/2006)	

3.2 Ignition risk analysis

An assessment must be made of the possibility of a source of ignition and its efficiency in igniting the explosive atmosphere. In order to make this assessment we must have detailed information about the flammability and explosive properties of the explosive atmosphere. In this analysis we must include all ignition sources described in the table 2.

Table 2. Ignition sources according to EN 1127-1 [2]

Ignition sources		
Possible	Helpful (yes/no)	Efficiency
Hot surfaces		
Flames and hot gases (including hot particles)		
Mechanical sparks		
Electrical equipment		
Vagabond electric currents, cathodic corrosion protection		
Static electricity(spark discharges, corona discharges, brush discharges, propagating brush discharges, cone discharges)		
Lightning (atmospheric discharges)		
Radio frequency (RF) electromagnetic waves from 10^4Hz la$\times10^{11}$Hz		
Electromagnetic waves from 3×10^{11}Hz la 3×10^{15}Hz		
Ionizing radiation		
Ultrasonics		
Adiabatic compression and shock waves		
Exothermic reactions including self-ignition of dust		
Classification Ex: Zone 1 şi Zone 2		
The equivalent level of protection corresponds to the area where the potential ignition source is identified		

In order to identify the ignition sources, all the components of the installation must be analyzed, as well as the materials that are involved. Electrical and non-electrical equipment and associated connection devices must be considered.

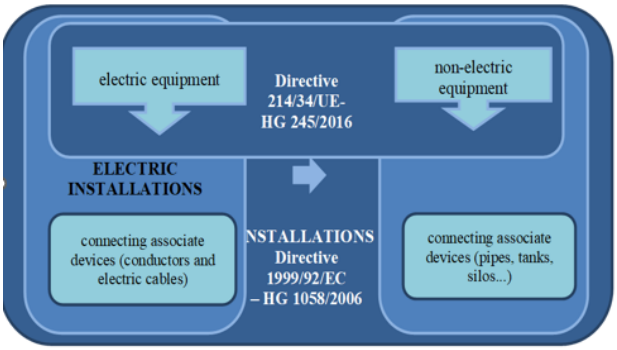

Fig. 3. Areas of the ATEx Directives

With regard to equipment and protective systems intended for use in potentially explosive atmospheres, Directive 2014/34/EU [1] regulates the obligations of manufacturers to assess such equipment for compliance with the requirements of the Directive and to guarantee for certain areas of use. The scope of the Directive also includes safety devices, control devices and control devices intended for use outside potentially explosive atmospheres, but which are necessary or which contribute to the operation of equipment and protective systems with regard to explosion risks.

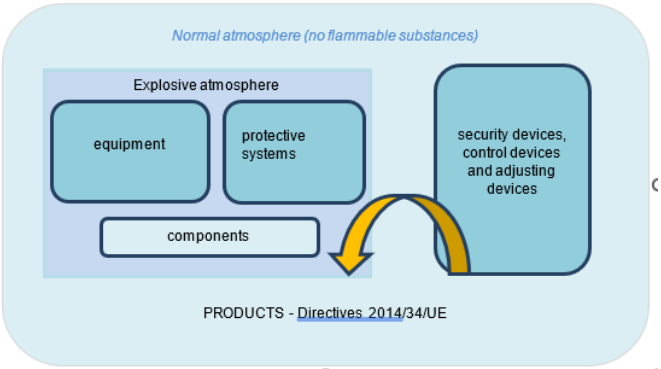

Fig. 4. The scope of the ATEX Directive 2014/34/EU

According to the ATEx directive, equipment is classified into categories according to the levels of protection it achieves (Table 3).

Tabel 3. Classification of equipment according to ATEX Directive 2014/34 /EU

Avoid initiation sources	**Required level of protection**	**Group II CATEGORY**	**EPL**
During normal operation	NORMAL	3	Gc
Also during foreseeable failures (one defect)	HIGH	2	Gb
Also during rare failures	VERY HIGH	1	Ga
Directive 2014/34/EU (HG 245/2016).			

3.3 Explosion risk assessment

The risk of explosion is given by the probability that a source of ignition will occur at the same time as an explosive atmosphere. In this sense, the stipulated term of use has appeared, which is defined as follows: Use of equipment, protective systems and devices in accordance with the group and category of equipment as specified in the ATEx Directive 2014/34/EU [1] and taking into account all information provided by the manufacturer that is necessary for the safe operation of equipment, protective systems and devices.

This term was necessary to establish a common language between designers and users, and SR EN 1127-1 [2] was developed in order to provide guidance in accordance with the requirements of Directives 2014/34 /EU [1] and 1999/92/EC both for the methodology of risk assessment when working with substances that may generate an explosive atmosphere and for the choice equipment and the establishment of appropriate protection measures depending on the probability of the explosive atmosphere.

As a general rule, when the presence of an explosive atmosphere is very likely, the use of equipment with a low probability of generating a source of ignition will be used. On the contrary, if the probability of the presence of an atmosphere is low, it will be possible to use equipment built to less stringent specifications.

Therefore, starting from the classification of hazardous areas in "ZONES" and from the classification of equipment into categories, the equipment must be selected according to the table 4.

Table 4. Choice of equipment depending on the type of atmosphere

ZONE	**Presence of an explosive atmosphere**	**Ignition sources avoidance**	**Level of protection required**	**Group II category**	**EPL**
2	Infrequent or only on a short period of time	during normal operation	NORMAL	3G	Gc
1	Likely to occur	also during foreseeable malfunctions (one defect)	HIGH	2G	Gb
0	Continuously, for long periods of time or frequently	also during rare malfunctions (two defects independent)	VERY HIGH	1G	Ga
USERS Directive1999/92/EC (HG 1058/2006)		**MANUFACTURERS** European Directive 2014/34/UE (HG 245/2016)			

The same is done for dust atmospheres, with the difference that the areas are 20,21,22, and the equipment is of category 3D, 2D, 1D, respectively protection level (EPL) Dc, Db, Da.The extent of protection measures depends on the probability of explosive atmospheres and must be determined for all types of ignition sources according to the table 5.

Table 5. Probability of ignition sources depending on the area

Zoning	**Reliable ignition sources:**
0 or 20	• in normal operation (no malfunctions) • in foreseeable cases of malfunction and • in the event of rare malfunctions
1 or 21	• in normal operation (without malfunctions) and • in foreseeable cases of malfunction

2 or 22	• in normal operation (no malfunctions)

As explosive atmospheres and ignition sources cannot be avoided with sufficient safety in many situations, measures must be taken to limit the effects of an explosion to an acceptable extent.

Measures to reduce the effects :

- pressure resistant design
- release of pressure
- suppression of the explosion
- prevention of the spread of the explosion flame

These measures are related to reducing the dangerous effects of explosions inside the installations but structural measures such as explosion walls can also be adopted.

The explosion protection measures listed so far can be kept functional, monitored or triggered by regulation, control and safety devices called process control technologies - PCE (Process Control Engineering). PCE devices are generally used to prevent dangerous explosive atmospheres or ignition sources or to reduce the harmful effects of an explosion.

The reliability of the PCE devices together with the technical and organizational measures taken must guarantee that the danger of an explosion is limited to an acceptable level, in all operating conditions. In some cases, it may be useful to combine PCE devices to prevent ignition sources with PCE devices to prevent hazardous explosive atmospheres.

4 Competences and responsibilities

In order to reduce the risk of explosions, the competence of all persons with responsibilities and responsibilities in the field of explosion prevention and protection is very important: manufacturers, equipment users, persons involved in repair, service and inspection activities as well as nominated third party assessment and control bodies. in legislation (NRDI INSEMEX, ITMs) as well as the persons involved in the explosion risk assessment. They must have specific knowledge of:

- protection and prevention of explosions
- risk assessment methods
- quality assurance, including the principles of auditing, documentation, traceability of measurements and calibration of instruments.

The legislation in force establishes requirements regarding the proof of competence for each of them.

Employers must provide training to workers to inform them of workplace explosion hazards and protective measures taken.

5 Conclusions

As explosions can cause human casualties and immeasurable property damage, risk assessment of explosions and the establishment of appropriate measures to reduce them to acceptable levels in accordance with the rules and standards in force are of particular importance for the safety and health of persons and property.

An essential element in assessing the risk of explosions in workplaces where explosive atmospheres may occur is the installations which must be designed, manufactured, installed and maintained in such a way that they cannot generate sources of ignition. Explosion prevention and protection requirements are regulated in specific norms and standards, and a good part of the explosion risk assessment refers to the evaluation of the conformity of the equipment / installations with the respective requirements.

This work was carried out through the "Nucleu" program of the National Research, Development and Innovation Plan 2022-2027, supported by MCID, project no. PN23320102.

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