ASPECTS REGARDING THE ASSESSMENT OF EQUIPMENT/INSTALLATIONS REGARDING COMPLIANCE WITH EXPLOSION PREVENTION REQUIREMENTS

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Abstract: According to the legislation regarding the minimum requirements for ensuring the safety and health of workers in the industry, the employer must take all measures to ensure the safety and health of workers, being obliged to be in possession of a risk assessment, in which an essential chapter is the risk generated by the equipment and installations used. If the installations are located in an area where an explosive atmosphere may be present, an explosion risk assessment must be made in order to establish adequate protective measures to prevent ignition sources that could initiate the explosive atmosphere. If for the equipment put on the market in accordance with the ATEx Directive, the evaluation methods with the essential dry and wet requirements are clear, for the installations carried out in situ by the user, there is no recognized method for evaluating the risk of explosions. The paper presents some aspects regarding the evaluation method of the installations used in environments with potentially explosive atmospheres in accordance with the requirements of the norms and standards regarding the prevention of explosions. Also, the work presents some aspects regarding the evaluation of the risk of explosion in the equipment already installed in specific conditions.

Key words: explosion risk, explosive atmosphere, risk assessment, ignition sources, methods.

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

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in assessing the risks of explosion when they are installed in environments with a potentially explosive atmosphere [1].

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.

2. APPLICABLE LEGISLATION

The placing on the market of equipment for explosive atmospheres is regulated by the ATEx Directive 2014/34/EU which establishes the manufacturer's obligations regarding the assessment of compliance with the essential health and safety requirements The evaluation of the equipment aims to prevent sources of ignition in normal or faulty operation, taking into account the intended use.

ATEx Directive 2014/34/EU, formerly known as ATEX 100a, is aimed at manufacturers. It applies to equipment and protective devices intended for use in potentially explosive atmospheres. Safety and controlling devices for use outside the hazardous area but essential for the safe operating of equipment inside it are also covered (fig.1). The directive applies to electrical as well as mechanical equipment and applies to gases, vapours and dust atmospheres.

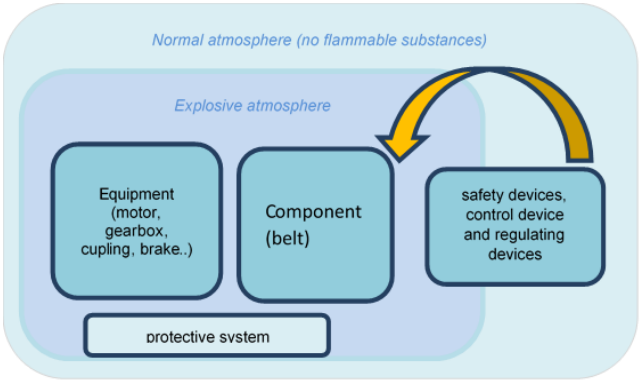

Fig.1. Scope of the directive ATEX 2014/34/EU

'Equipment' means machines, apparatus, fixed or mobile devices, control components and instrumentation thereof, and detection or prevention systems which, separately or jointly, are intended for the generation, transfer, storage, measurement, control and conversion of energy for the processing of material, and which are capable of causing an explosion through their own potential sources of ignition.

'Protective systems' means design units which are intended to halt incipient explosions immediately, and/or to limit the effective range of explosion flames and explosion pressures. Protective systems may be integrated into equipment or separately placed on the market for use as autonomous systems.

'Components' means any item essential to the safe functioning of equipment and protective systems but with no autonomous function.

'Safety devices, controlling devices and regulating devices' means devices intended for use outside potentially explosive atmospheres but required for or contributing to the safe functioning of equipment and protective systems with respect to the risks of explosion.

'Assembly' means a combination of two or more pieces of equipment, together with components if necessary, placed on the market and/or put into service as a single functional unit. Assemblies can be placed on the market in different ways.

Assemblies with a fully specified configuration of parts are put together and placed on the market as a single functional unit by the manufacturer of the assembly. The manufacturer assumes responsibility for compliance with the directive and must therefore provide clear instructions for assembly, installation, operation and maintenance, etc.

Assemblies forming a modular system. In this case, the assembly is not necessarily completed by the manufacturer of the product and placed on the market as a single functional unit. However, the user/installer selects and combines the parts from a manufacturer of origin for a given range, the manufacturer is still responsible for the compliance of the assembly with the directive.

'Installation' means a combination of two or more pieces of equipment which were already placed on the market independently by one or more manufacturers. Installing and combining the equipment on the user's premises is not considered manufacturing and therefore the resulting installation is outside the scope of ATEX Directive 2014/34/UE but will be subject to the legal requirements applicable such as Directive 1999/92/EC (ATEX 137) [4] or Directive 92/104/EEC [2].

In this case, the evaluation of the explosion risk is an obligation of the employer who must draw up a "explosion protection document" in accordance with HG 1058/2006 (Directive 1999/92/EC] if it is about industries other than mining, respectively draw up a "document of security and health", as regulated in GD 1049/2006 (Directive 92/104/CEE) in the case of mining aria [3].

The explosion risk assessment process focuses first 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 an explosive atmosphere to a minimum acceptable level according to applicable norms and standards.

3. RISK REDUCTION. FUNDAMENTAL PRINCIPLES

The need for the simultaneous presence of an explosive atmosphere and the effective source of ignition and the foreseeable effects of an explosion lead directly to the three basic principles of explosion prevention as well as explosion protection:

a) Prevention

1) avoiding explosive atmospheres. This objective can be achieved, to a large extent, by changing either the concentration of the flammable substance to a value that is outside the explosion range, or the concentration of oxygen to a value below the limit oxygen concentration (LOC);

2) avoiding all possible sources of effective ignition. This is achieved through the appropriate design of the equipment, protection systems and components.

Note: In certain cases, especially in mining, an essential measure to prevent explosions is the de-energization of equipment containing ignition sources, when there is an explosive concentration.

b) Protection: limiting the effects of explosions to an acceptable level. This can be achieved, up to a certain limit, by protective constructive measures. Unlike the measures described previously, in this case, the occurrence of an incipient explosion is taken into account.

The elimination or minimization of the risk can be achieved by applying one or more of the principles of prevention or protection mentioned above. Avoiding an explosive atmosphere must always be the first option.

The greater the probability of the occurrence of an explosive atmosphere, the greater must be the extension of measures against actual ignition sources and vice versa. When flammable substances are involved that can generate an explosive atmosphere, we cannot speak of zero risk of explosions but only of a maximum 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 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).

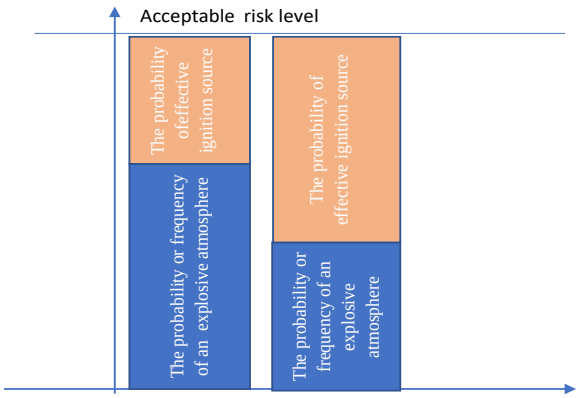

Fig.2. Maximum acceptable ignition risk

In order to enable the selection of appropriate measures, an explosion safety concept must be developed for each individual case.

For this, the norms and standards of ATEx have classified the equipment into categories depending on the level of protection it provides and the spaces where

explosive atmospheres can occur have been classified into zones depending on the duration and probability of the persistence of the explosive mixture.

Thus, the ATEX directive classifies mining equipment (Group I) into 2 categories (M1, M2) and the others (Group II) into 3 categories (1,2,3).e

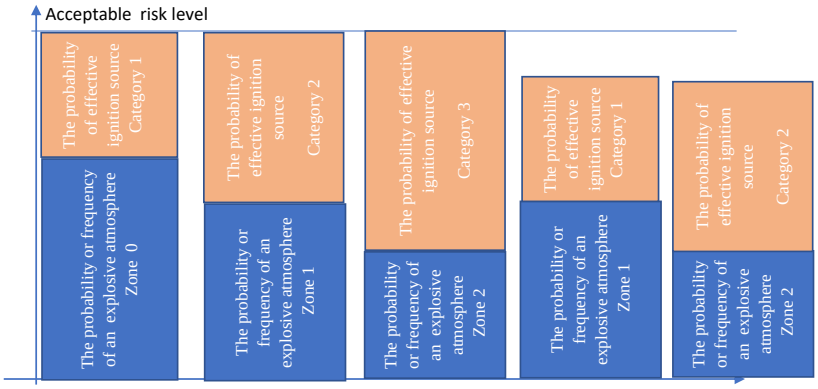

Fig.3. Risk of explosion of Group II equipment

Equipment category 1 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and ensuring a very high level of protection.

Equipment in this category is intended for use in areas in which explosive atmospheres caused by mixtures of air and gases, vapours or mists or by air/dust mixtures are present continuously, for long periods or frequently (zona 1 conform SR EN 60079-10-1 [5]).

Equipment in this category must ensure the requisite level of protection, even in the event of rare incidents relating to equipment, and is characterised by means of protection such that:

— either, in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection,

— or the requisite level of protection is assured in the event of two faults occurring independently of each other.

Equipment category 2 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and of ensuring a high level of protection.

Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists or air/dust mixtures are likely to occur occasionally (zona 1 conform SR EN 60079-10-1).

The means of protection relating to equipment in this category ensure the requisite level of protection, even in the event of frequently occurring disturbances or equipment faults which normally have to be taken into account.

Equipment category 3 comprises equipment designed to be capable of functioning in conformity with the operating parameters established by the manufacturer and ensuring a normal level of protection.

Equipment in this category is intended for use in areas in which explosive atmospheres caused by gases, vapours, mists, or air/dust mixtures are unlikely to occur or, if they do occur, are likely to do so only infrequently and for a short period only (zona 2 conform SR EN 60079-10-1).

Equipment in this category ensures the requisite level of protection during normal operation.

Unlike surface industries, in grit mines electrical and non-electrical equipment and mining personnel are in permanent contact with gas and/or dust/air mixtures which, under unfavorable conditions, can form explosive atmospheres. That is why specific, stringent security requirements are regulated for explosion protection and evacuation possibilities in dangerous situations.

Traditionally, a safety factor has been introduced, which is a common practice of the member states of the European Union, to de-energize the equipment or make it safe and to withdraw the mining personnel from the workplaces, if the atmospheric conditions exceed a certain percentage of the lower explosion limit (LEL) of methane (grey) in air, as provided for in the relevant national legislation of the Member State.

NOTE – Current limit values for disconnection of equipment and withdrawal of personnel differ in each member state.

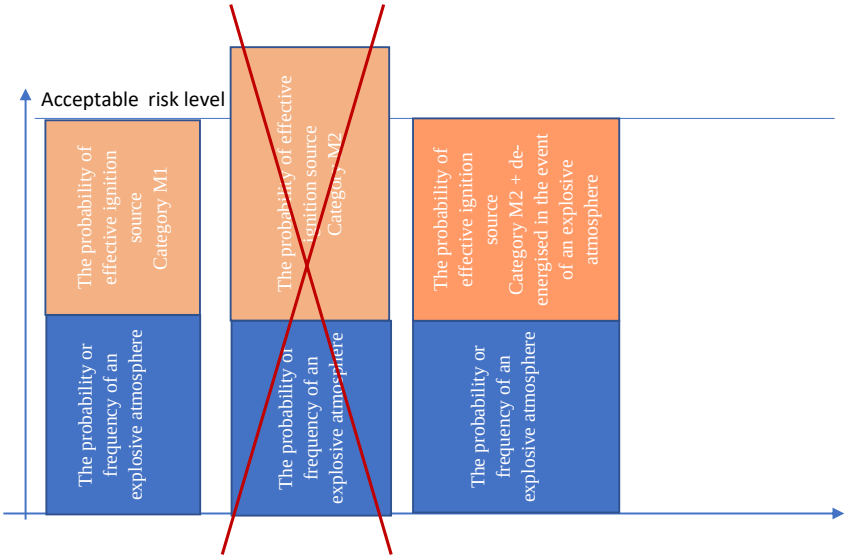

Fig.4. Risk of explosion of Group I equipment - mining

Equipment category M 1 comprises equipment designed and, where necessary, equipped with additional special means of protection to be capable of functioning in conformity with the operational parameters established by the manufacturer and ensuring a very high level of protection.

Equipment in this category is intended for use in underground parts of mines as well as those parts of surface installations of such mines endangered by firedamp and/or combustible dust.

Equipment in this category is required to remain functional, even in the event of rare incidents relating to equipment, with an explosive atmosphere present, and is characterised by means of protection such that:

— either, in the event of failure of one means of protection, at least an independent second means provides the requisite level of protection,

— or the requisite level of protection is assured in the event of two faults occurring independently of each other.

Equipment category M 2 comprises equipment designed to be capable of functioning in conformity with the operational parameters established by the manufacturer and ensuring a high level of protection.

Equipment in this category is intended for use in underground parts of mines as well as those parts of surface installations of such mines likely to be endangered by firedamp and/or combustible dust.

This equipment is intended to be de-energised in the event of an explosive atmosphere.

The means of protection relating to equipment in this category assure the requisite level of protection during normal operation and also in the case of more severe operating conditions, in particular those arising from rough handling and changing environmental conditions.

4. EXPLOSION RISK ASSESSMENT

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 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 [11], SR EN 80079 [12] or standards with basic concepts and methodology for explosion prevention and protection - SR EN 1127-1[7] and SR EN 1127-2[8]. 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 and 1999/92/EC. 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);

- 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.

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.

5. 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).

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 5).

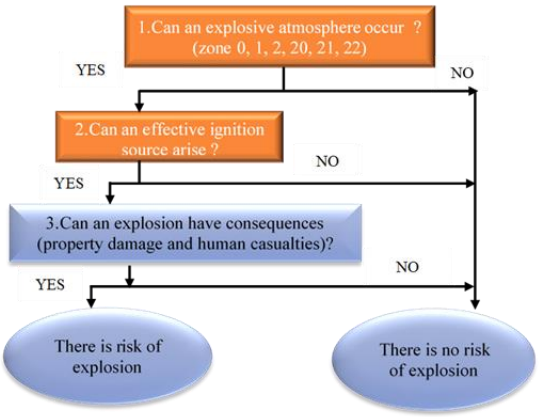

Fig.5. Assessement of explosin risk

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.

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 3□106 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 [9] can be applied to ignition risk assessment.

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 [6] (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 standard together with the series of standards SR EN 60079, SR EN 80079 on the types of protection, including SR EN 60079-14 [10], for the requirements for mounting equipment in ex areas and SR EN 15198 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.

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. 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. 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.

6. 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 or GD 1049/2006 transposing Directive 92/104/EEC

If the installation was placed on the market as an assembly by the manufacturer, who assessed the assembly for compliance with the requirements of the ATEx Directive 2014/34/EU, no further assessment is required, but if the installation was built by the user (employer) by assembling the components in situ, he must make an initial assessment, upon commissioning, as a manufacturer.

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

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.

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.

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