Study on common aspects of the types of protection for electrical equipment used in explosive atmospheres

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Abstract. The evaluation of explosion-proof electrical equipment for certification is particularly important given the risk of explosion and must be minimized. This in order to ensure the safety of life, health of workers, to prevent damage to goods and the environment when they meet the essential security requirements at European level. Directive 2014/34 / EU states that equipment used in explosive atmospheres must be designed to operate without endangering the environment for which it is intended. This paper presents a comparison between the types of protection for electrical apparatus by comparing some common characteristics that are important for maintaining the integrity of explosion protection. Consequently, this paper intends to be the precursor of a practical guide for the selection and implementation of different types of protection on the apparatus intended for use in areas with hazard of explosive atmospheres, both for designers and manufactures.

1 Introduction

Generally speaking, designing and manufacturing of electrical apparatus benefits lately of special advantages, offered by the appearance of new components (integrated) and technologies, which makes the time that passes from enouncing the idea until physical achievement of the apparatus to be relatively short, and the process involved by that to be a monotonous one.

But, when the problem of adapting this apparatus to the particularities of use them in atmospheres with explosion hazard, the above mentioned process is considerably slowed, not by the missing of consecrated components for such processes, but especially by the leak of experience and knowledge regarding the standard requirements, referring to construction and using of electrical apparatus in areas with hazard of explosive atmosphere.

This state of fact is negatively more emphatic because, lately, the groups of standards from this field in the world, Europe and Romania have a peculiar dynamic caused especially by the homogenisation and generalisation process opened and maintained by IEC.

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Considering the above mentioned, this paper proposes to help the designers and manufacturers of electric apparatus designed to be used in areas with hazard of explosive atmosphere by displaying a comparative study regarding definitive aspects for applicable types of protection.

2. Classification of explosive atmospheres. Hazard of explosion

In order to speak about an explosion, three factors must exist at the same time and in the same space. These factors form the triangle of explosion hazard (fig. 1):

- Presence of flammable substances in form of gases, vapours, mists.
- Presence of oxidant substance, air or oxygen, as support for violent combustion (explosion).
- Presence of ignition source in form of sparks and hot surfaces.

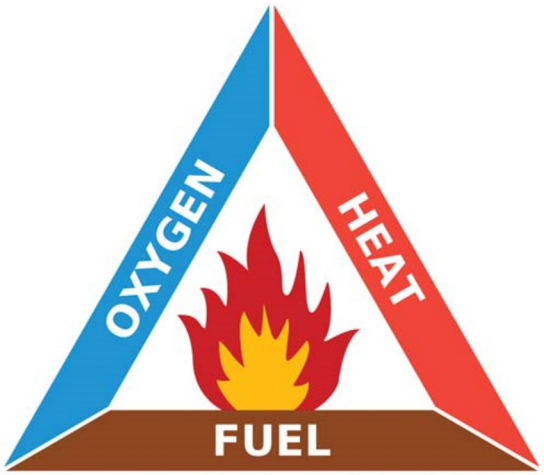

Fig. 1. Ignition triangle.

2.1 Types of protection – short description

The type of protection represents a technical solution by which at least one of the factors, represented in the ignition triangle is removed or limited below the critical values.

Flameproof enclosure;

Represents a type of protection that permits to have an explosion inside equipment, but which by the characteristic elements for this type of protection (flameproof joints) makes that explosion not to be transmitted to the explosive atmosphere that surrounds the enclosure. Generally, it is used for power apparatus, but can also be used for other kinds of apparatus.

Increased safety:

A type of protection which consists in applying some supplementary measures to avoid producing electric arcs, sparks, or excessive temperatures on any part of electrical apparatus (internal or external). These phenomena are not produced even in normal operation.

Non-incendive:

Represents a type of protection which is based on the other types of protection principles, but it contains less rigorous prescriptions than those contained in the standards for types of protection eligible in zone 1. This type of protection is only eligible for zone 2.

Intrinsic safety:

Represents a type of protection by which electrical parameters are safely limited so than the ignition source to be limited to a non hazardous value. This is also a consecrated type of protection for "low currents" applications.

Encapsulation:

It is a type of protection by which the small kind apparatus is separated from hazardous atmosphere by moulding / enclosing in compound.

Pressurization:

It's a type of protection by which the apparatus (often) in normal construction is placed inside an enclosure in which a protective gas is circulated so as in the inner space the explosive gas concentration is much lower than the lower explosive limit (LEL). Pressurization remains the only available solution for high frame sizes apparatus.

3 Comparative study for the types of protection

3.1 Age

The types of protection showed up like technical punctual solutions to protect the electrical equipment for use in surface or underground areas, which involves the occurrence of explosive atmospheres [1].

The oldest types of protection are flameproof enclosure "d", which appeared at the end of the 19th century, oil immersion "o", sand filling "q", pressurization "p" and intrinsic safety "i" which appeared around 1930, their use and standards occurrence for them being noticed even from the first half of the 20th century [2].

Then after the second half of the past century started to be use the types of protection increased safety "e" (standardized in 1969) and encapsulation "m" (standardized in 1988).

At the end of the 20th century the types of protection oil immersion (o) and sand (powder) filling (q) were less and less used and leave the place for a composite type of protection which has some "soften" requirements regarding the type of protection. This type of protection was called non-incendive (n) and has a few subtypes like nA, nL, nC, nR [3].

3.2 Incidence on equipment

Regarding the usage frequency, it is relatively hard to do a documented (objective) study especially because the information regarding this subject are disparate and the study of certified / tested articles in INSEMEX Petroşani offers a unilateral image of this issue [4].

Based on authors experience the following conclusions can be exposed:

The type of protection flameproof enclosure (d) is one of the most used types of protection for electrical apparatus operating in areas with hazard of explosive atmosphere as well for the power part and low current part. The tendency remarked regarding the use of this type of protection it's a low decreasing one especially because the appearance and use of other types of protection [5].

Increased safety (e), pressurization (p), non-incendive (nA and nL) shows an increasing tendency regarding the usage owned especially to the less rigorous requirements comparative with the type of protection flameproof enclosure "d" and intrinsic safety [6].

Intrinsic safety (i) keeps and consolidates its position being the direct applicable solution for low currents apparatus and systems [7].

Encapsulation (m) has a low incidence, but the tendency is to slowly increase [8].

Oil immersion (o) and powder (sand) filling (q) are types of protection practically unused.

3.3 Eligibility for hazardous zones

All types of protection are eligible for Zone 1 (db, e, ib, q, o, mb, px, py), except the types of protection non-incendive (n), intrinsic safety – level of protection "ic", pressurization "pz" which are eligible only for Zone 2 [9].

Zone 0 necessitates special considerations, and intrinsic safety – level of protection ia, da and encapsulation level of protection ma are (for the moment) the only types of protection eligible to use in such areas [10].

Requirements regarding mechanical protection

The requirements regarding normal degree of protection of enclosures varies from minimum to medium as a function of the types of protection (Table 1).

Table 1. Degree of protection requirements related to the type of protection.

Type of protection (symbol)	Degree of protection
Intrinsic safety (i)	IP 20
Pressurization (p)	IP 40
Increased safety (e)	IP 44 (insulated conductive live parts) IP 54 (bare conductive live parts) IP 20 (rotating electrical machines installed in clean environments and regularly supervised by trained personnel)
Non-incendive	IP 54 IP 20 (rotating electrical machines installed in clean environments and regularly supervised by trained personnel)

3.4 Creepage distances and clearances

For the comparative study of those distances the clearance was chosen having as reference the value imposed by the type of protection increased safety (e) [6].

For accomplishing the comparison the downgrade of the regression line was used (fig.2).

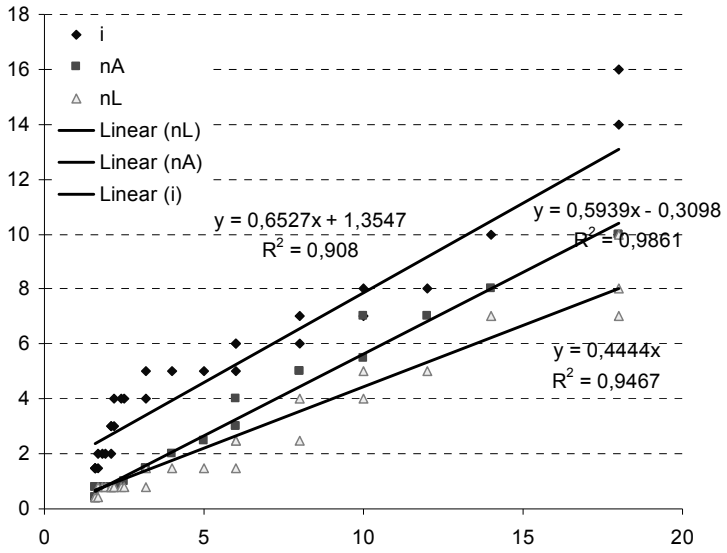

Fig. 2. Clearance at different voltages for the types of protection i, nA, nL function of the clearance imposed by the type of protection increased safety (e).

Taking into account the above mentioned criteria it can say that the type of protection increased safety prescribes the largest clearances, being followed by the type of protection intrinsic safety, non-incendive nA and respectively nL, at approximately half values [4].

3.5 Maximum voltage

The maximum admitted voltage values for the types of protection are given in table 2.

Table 2. Maximum admitted voltage for different types of protection.

Type of protection (symbol)	Maximum voltage [kV]
Intrinsic safety (i)	1.575
Non-incendive (nL)	15.6
Encapsulation (m)	11
Pressurization (p)	11
Increased safety (eb/ec)	11/15
Flameproof enclosure (d)	-
Non-incendive (nA)	15.6

3.6 Technical protection solution

Taking into account the protection strategy mentioned in the beginning of the paper four technical solution of protection can be stated, like this:

- segregation – separates the ignition source (apparatus), from the explosive atmosphere. The types of protection pressurization (p), encapsulation (m), oil immersion (o), powder filling (q) are based on this t eliminates the source of ignition [11].

The types of protection increased safety (e) and non-incendive (nA) are based on this technical protection solution;echnical protection solution [12];

- limitates the energy of ignition source. The types of protection intrinsic safety (i) and non-incendive (nL) are based on this technical protection solution;
- limitates the deflagration expansion zone. The type of protection flameproof enclosure (d) is based on this technical protection solution.

4 Conclusions

The purpose of the paper is to emphasize the importance and role of the types of protection applied to electrical equipment used in explosive environments as well as the method of application. The common aspects of these types of protection that can be applied to electrical equipment have also been highlighted in order to ease the designers' work in choosing the most effective and safe means of protection for an electrical equipment. This paper had the purpose to compare some common characteristics of the types of protection. By the study made, some aspects that recommend various types of protection for one specific application (apparatus) were underlined.

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