Dynamics of the standardization process for explosive atmospheres

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Abstract. This paper presents an overview of the standardization activity in the field of explosive atmospheres both at the national and international level, as well as the evolution of this activity in different areas related to these explosive atmospheres. In the first part of the paper, the aspects regarding explosion risk, explosion prevention and protection, classification of explosive atmospheres, as well as factors influencing explosion protection are briefly presented. In the second part of the paper, the context of standardization at the national level is presented together with the reference institutions in the field of standardization for or in relation to explosive atmospheres. On this occasion, the international institutions that administer the standards that have an impact in the field of regulations for explosive atmospheres at the national level are also presented. In the last part of the paper, the analysis carried out for several representative standards in the field of explosion protection is presented, from the point of view of the significant changes made in the current edition compared to the previous edition.

1 Introduction

With the discovery of new energy sources during the second industrial revolution at the end of the 19th century, the development of industrial branches such as the electrical, chemical, and automobile industries began. The increasing use of flammable substances in the production process led to the emergence of the notion of hazardous locations or hazardous atmospheres in terms of both fire and explosion hazards.

Since then and until today, all those involved in these industrial branches (both those in the management of factories and plants and the authorities responsible in the field) have contributed to the elaboration, development and issuing of protective measures and rules to be respected to avoid accidents at work in these dangerous atmospheres.

Thus, in 1901, the first national standards body in the world was founded in London under the name Engineering Standards Committee, which in 1918 became the British Engineering Standards Association [1].

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In Romania, the first organization responsible for national standardization was founded in 1928 under the name of the Romanian Industry Standards Commission, from which the Romanian Institute of Standardisation was later derived in 1970 [2].

2 Risk of explosion

The risk of explosion occurs when the flammable/combustible substance in the atmosphere is in sufficient/optimum concentration so that in combination with the surrounding air it forms a mixture that can be ignited if there is an efficient ignition source.

Prevention of the risk of explosion can be done by applying specific measures either to prevent the formation of an explosive atmosphere or to prevent the ignition of an explosive atmosphere [3].

The formation of an explosive atmosphere can be prevented by limiting the concentration of the flammable substance present, using an effective ventilation system and a concentration monitoring system.

Ignition of the explosive atmosphere formed can be avoided by separating the ignition source from the explosive atmosphere, eliminating it, or limiting its ignition capability. The ignition source can be:

- of a thermal or electrical nature, originating from electrical or mechanical equipment used in that atmosphere; or
- caused by static electricity, lightning, electromagnetic waves, ionizing radiation, ultrasound, adiabatic compression, shock waves, and exothermic reactions.

In addition to the application of measures to prevent the risk of explosion, protective measures against aggravation of the consequences of explosion are considered. This objective is implemented by stopping the explosion and/or limiting the explosion range to an acceptable extent, using protective systems.

Depending on the type of flammable/combustible substance present in the atmosphere under study (gas/vapour or dust), frequency and duration of occurrence, degree and flow rate of release, and depending on the type and degree of ventilation used to dilute the concentration of flammable/combustible substance, explosive atmospheres have been classified into zones (flammable gases/vapours - Zone 0, Zone 1, Zone 2; combustible dust - Zone 20, Zone 21, Zone 22) [4,5].

This zoning of potentially explosive atmospheres, together with the grouping of gases/vapours or dust and their ignition temperature, is an important criterion for the selection of electrical or non-electrical equipment to be used in these zones.

Depending on the type and functional role of the equipment, protective measures and techniques, called explosion protection types, have been designed and developed for electrical and non-electrical equipment so that they can be used safely in potentially explosive atmospheres [6].

Explosion protection of equipment and installations intended for use in potentially explosive atmospheres is influenced by three factors, namely:

a) design, assembly and commissioning activities,

b) activities of use/operation, inspection and maintenance, and

c) environmental factors such as humidity, temperature range, presence of corrosive substances and presence of dust.

These factors are shown graphically in Figure 1.

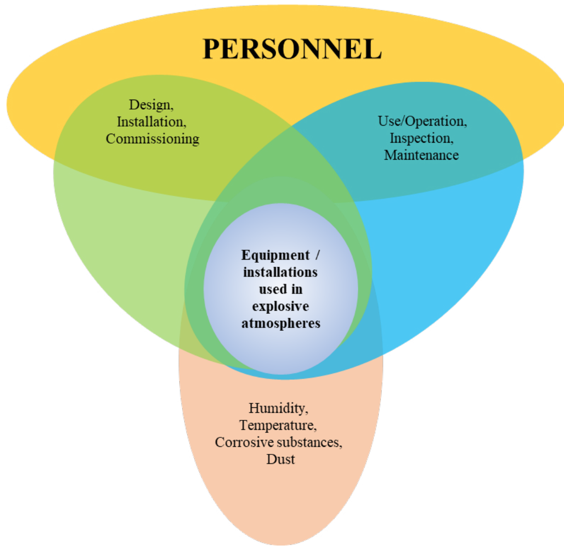

Fig. 1. The factors which influence explosion protection.

All these aspects of explosion protection have been and are included in standards specific to the field of explosive atmospheres, documents that have become the basis for the implementation of occupational safety and health requirements.

3 Context of standardization at national, European and international level

3.1 In Romania

At the moment, in Romania, the Romanian Standardization Association (ASRO) is the national standardization body [2, 7, 8]. It was established in 1998, as a non-profit association, by taking over the assets of the Romanian Standardization Institute and the National Training and Management Center for Quality Assurance.

The standardization activity within ASRO is organized into 14 standardization sectors (fields of activity) which include 399 technical committees (TC), of which, at the moment, 358 are active. The component of each technical committee is based on the following structure:

- members,
- president,
- secretary,
- ASRO expert.

The activity carried out within the technical committee includes, among others, the development of new original Romanian standards and their maintenance, the adoption of standards and other European and international standardization documents as Romanian standards and the development of the Romanian version of European and international standards adopted at the national level.

Also, an important aspect of the technical committee's activity is the participation in the European and international standardization activity by appointing Romanian experts in the working groups of the European and international technical committees for which there is interest.

When developing an original Romanian standard, the following stages are considered:

- the submission to ASRO of the proposal for a new standard theme by the author of the proposal, accompanied by the preliminary draft of the proposal to be assigned to the relevant technical committee;
- elaboration and approval of the project in the relevant technical committee;
- submission of the committee project to the ASRO representative for starting the public investigation;
- the implementation of the observations received as a result of public inquiries in the draft standard that must be subject to approval in the specialized departments of ASRO;
- submission of the draft standard for approval by the Director General of ASRO and its publication.

The adoption of standards and other European and international standardization documents (for example technical reports or specifications, guides) as Romanian standards can be done by the following methods:
- publication of the Romanian version;
- publication by reproduction of an official version (English, French or German), i.e. through the confirmation tab;
- the method of confirming the adoption by publishing, in the "Bulletin of Standardization", an announcement (confirmation note).

At the national level, the standards in the field of explosive atmospheres are included in the "Electrical and electronic equipment" sector by the technical committee ASRO/CT 137 Equipment for explosive atmospheres.

3.2 In Europe

Today, at the European level there are three European standardization organizations officially recognized by the European Union [9, 10]:
- European Committee for Standardization (CEN), established in 1961; is responsible for standardization in all sectors of life and brings together national standardization bodies from 34 European countries;
- The European Electrotechnical Committee for Standardisation (CENELEC), created in 1973; develops standards in the electrotechnical field and brings together national standardization bodies from 34 European countries;
- European Telecommunications Standards Institute (ETSI), was founded in 1988 and is responsible for standardization in the field of information and communications technology.

All these have the role of developing standards to support the regulations and policies of the European Union, the only ones recognized as European standards (EN).

ASRO is a member with full rights in all these three European standardization organizations.

At the European level (CEN and CENELEC), the standards in the field of explosive atmospheres are included in the Occupational Health and Safety sector through the technical committees CEN/TC 305 Potentially explosive atmospheres - Explosion prevention and protection and CLC/TC 31 Electrical apparatus for potentially explosive atmospheres. The standards developed in these technical committees fall under the ATEX Directive 2014/34/EU which aims to create a single European market for products in explosion-proof construction [11]. In order to achieve this goal, several conditions must be met at the same time:
- the standards that correspond to the technical requirements of the ATEX Directive must specify clear and unequivocal compliance criteria;
- notified bodies for conformity assessment must be competent from a technical point of view, operate impartially and efficiently in order to impose minimum costs on the industry and not delay the works;

- there must be a mechanism that allows the notified bodies to harmonize their practices in order to reduce the differences between the bodies regarding the application of the technical requirements of the harmonized standards.

- The European Commission and the member states, through the competent authority at the national level, must supervise the application of the ATEX Directive by implementing the most appropriate level of security, in the most economical way.

National Institute for Research and Development in Mine Safety and Protection to Explosion INSEMEX Petrosani is the national body recognized by the European Commission (NOTIFIED BODY NB1809) for evaluating the conformity of products falling under the directives [12]:

- Directive 2014/34/EU "Equipment and protective systems used in potentially explosive atmospheres - ATEX",
- Directive 2014/28/EU "Explosives for civilian use"
- Regulation 2016/425 "Personal protective equipment"
- Directive 2013/29/EU "on the harmonization of the legislation of the member states regarding the making available on the market of pyrotechnic articles".

3.3 At the international level

At the international level, there are two recognized standardisation organisations:

a) International Electrotechnical Commission (IEC), founded in 1906 in London, whose vision is the development and publication of international standards for all electrical, electronic and related technologies; it brings together over 170 members countries and administers 4 conformity assessment systems [13]:

o IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components (IECEE).

o IEC System for Certification to Standards Relating to Equipment for Use in Renewable Energy Applications (IECRE).

o IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx).

o IEC Quality Assessment System for Electronic Components (IECQ).

b) International Organization for Standardization (ISO), founded in 1947 in Geneva, aims to develop and publish standards for all technical and non-technical fields other than electrical and electronic engineering; it brings together 168 national standards bodies [14].

ASRO is a full member of both IEC and ISO.

At the international level (IEC), standards in the field of explosive atmospheres are managed by technical committee TC 31 Equipment for explosive atmospheres and technical subcommittees SC 31G Intrinsically-safe apparatus, SC 31J Classification of hazardous areas and installation requirements, SC 31M Non-electrical equipment and protective systems for explosive atmospheres.

To facilitate international trade in equipment and services for use in explosive atmospheres, global unification of standards is needed. Concrete steps in this direction have been taken by initiating permanent arrangements for technical cooperation between CEN and ISO and between CENELEC and IEC.

The Vienna Agreement between CEN and ISO was signed in 1991 and establishes two essential modes for the collaborative development of standards: the mode under ISO lead and the mode under CEN lead, whereby documents developed within one body are notified to the other for simultaneous approval by both bodies [15].

The Dresden Agreement between CENELEC and IEC was signed in 1996 and after 20 successful partnerships, the cooperation between the two organizations was reconfirmed with the signing of the Frankfurt Agreement in 2016. Through this agreement the following goals were set: providing new CENELEC work items to the IEC; parallel voting of draft international standards; publication requirements; conversion of European standards into international standards [16].

4 Dinamica dezvoltarii standardelor din domeniul protectiei la explozie

As a result of the analysis carried out for the standards mentioned in Table 1, the following conclusions can be drawn regarding the evolution of standardization in the field of explosion protection [17]:

- at the national level, the first standards for equipment used in potentially explosive atmospheres were the STAS 6877 series published starting from the year 1973 and were intended only for electrical equipment and only for gaseous explosive atmospheres. Starting from the year 1995 this series of standards has been replaced by the SR EN 50014 - SR EN 50020 series and this series has been replaced by the SR EN 60079 series starting from the year 2005;
- Standards for electrical apparatus for use in the presence of combustible dust were adopted as Romanian standards starting from the year 1989;
- standards for non-electrical equipment for potentially explosive atmospheres were adopted as Romanian standards starting from the year 2003;
- starting from the year 2010, the new edition of the SR EN 60079 series of standards has been adopted, in which the requirements of the standards of the series for electrical equipment for explosive gas atmospheres have been merged with those of the series for electrical equipment for explosive dust atmospheres;
- SR EN 60079-28 is a relatively new standard (first published in 2007) that adds safety requirements for a new category of equipment intended for use in explosive atmospheres, namely optical equipment;
- SR EN ISO/IEC 80079-34, SR EN ISO 80079-36, SR EN ISO 80079-37 and SR EN IEC 60079-0 are proof of the achievement of the global unification of standards.

Table 1. Explosion protection standards.

Nr. Crt.	Indicativ standard si anul publicarii	Anul editiei anterioare	Titlu standard
1.	SR EN 1127-1:2019	2011	Atmosfere explozive. Prevenirea şi protecţia la explozie. Partea 1: Concepte fundamentale şi metodologie
2.	SR EN 1127-2:2014	2003	Atmosfere explozive. Prevenirea şi protecţia la explozie. Partea 2: Concepte fundamentale şi metodologie pentru minerit
3.	SR EN 15188:2021	2013	Determinarea comportării la autoaprindere a acumulărilor de praf
4.	SR EN IEC 60079-0:2018	2008	Atmosfere explozive. Partea 0: Echipamente. Cerinţe generale
5.	SR EN 60079-1:2015	2007	Atmosfere explozive. Partea 1: Protecţia echipamentului prin carcase antideflagrante "d"
6.	SR EN 60079-2:2015	2007	Atmosfere explozive. Partea 2: Protecţia echipamentului prin carcasă presurizată "p"

7.	SR EN 60079-7:2016	2011	Atmosfere explozive. Partea 7: Protecţia echipamentului prin securitate mărită "e"
8.	SR EN 60079-11:2012	2011	Atmosfere explozive. Partea 11: Protecţia echipamentului prin securitate intrinsecă "i"
9.	SR EN IEC 60079-15:2019	2003	Atmosfere explosive. Partea 15: Protecţia echipamentului prin tip de protecţie "n"
10.	SR EN 60079-18:2015	2010	Atmosfere explozive. Partea 18: Protecţia echipamentului prin încapsulare "m"
11.	SR EN IEC 60079-25:2022	2011	Atmosfere explozive. Partea 25: Sisteme electrice cu securitate intrinsecă
12.	SR EN 60079-28:2016	2007	Atmosfere explozive. Partea 28: Protecţia echipamentelor şi a sistemelor de transmisie care utilizează radiaţie optică
13.	SR EN 60079-31:2014	2010	Atmosfere explozive. Partea 31: Protecţia echipamentului împotriva aprinderii prafului prin carcasă "t"
14.	SR EN IEC 60079-10-1:2021	2016	Atmosfere explozive. Partea 10-1: Clasificarea zonelor. Atmosfere explozive gazoase
15.	SR EN 60079-10-2:2015	2010	Atmosfere explozive. Partea 10-2: Clasificarea ariilor. Atmosfere explozive cu praf
16.	SR EN 60079-14:2014	2009	Atmosfere explozive. Partea 14: Proiectarea, alegerea şi construcţia instalaţiilor electrice
17.	SR EN 60079-17:2014	2008	Atmosfere explozive. Partea 17: Inspecţia şi întreţinerea instalaţiilor electrice
18.	SR EN IEC 60079-19:2020	2011	Atmosfere explozive. Partea 19: Repararea, revizia generală și recondiționarea echipamentelor
19.	SR EN ISO 80079-36:2016	SR EN 13463-1: 2009	Atmosfere explozive. Partea 36: Echipamente neelectrice pentru atmosfere explozive. Metodă şi cerinţe de bază
20.	SR EN ISO 80079-37:2016	SR EN 13463-5:2011; SR EN 13463-6:2005; SR EN 13463-8:2004	Atmosfere explozive. Partea 37: Echipamente neelectrice pentru atmosfere explozive. Tip de protecţie neelectrică prin securitate constructivă "c", prin controlul surselor de aprindere "b", prin imersie într-un lichid "k"
21.	SR EN ISO/IEC 80079-34:2020	2012	Atmosfere explozive. Partea 34: Aplicarea sistemelor calităţii pentru fabricarea produselor Ex

The following charts show graphically the number of significant changes made in the current edition compared to the previous edition of the Table 1 standards under analysis. The three types of changes analyzed are:

- minor and editorial changes (Figure 2) which include clarifications, reductions in technical requirements, minor technical changes and editorial corrections;
- Extensions (Figure 3) which represent the addition of technical options;
- major technical changes (Figure 4) which represent the addition of technical requirements and increases in technical requirements.

In the diagram in Figure 2, it can be seen that some standards have more minor changes than others, such as SR EN IEC 60079-0:2018 and SR EN 60079-1:2015.

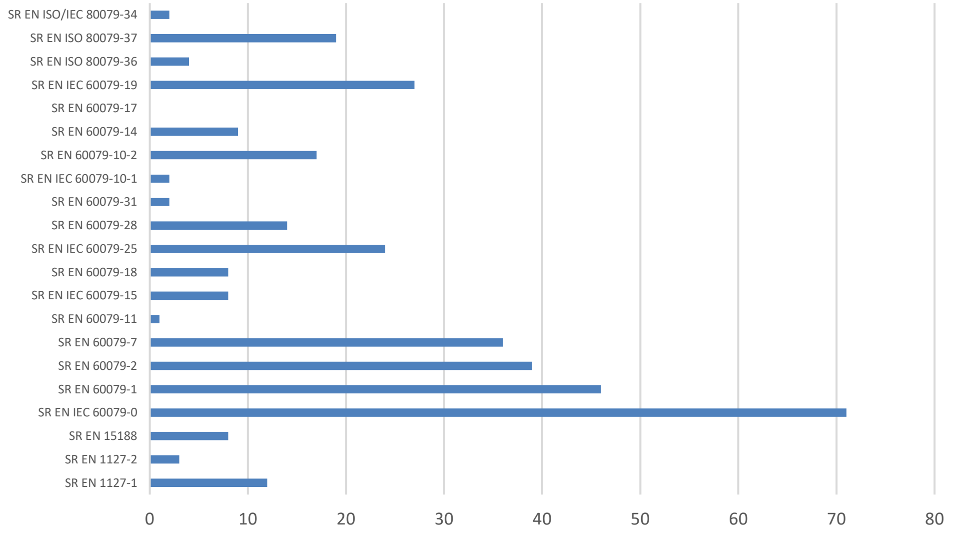

Fig. 2. The number of minor and editorial changes.

The diagram in Figure 3 shows the number of extensions for the current editions of the family of standards governing the field of explosion protection. Here, SR EN 60079-1:2015, SR EN IEC 60079-15:2019 and SR EN 60079-14:2014 can be distinguished.

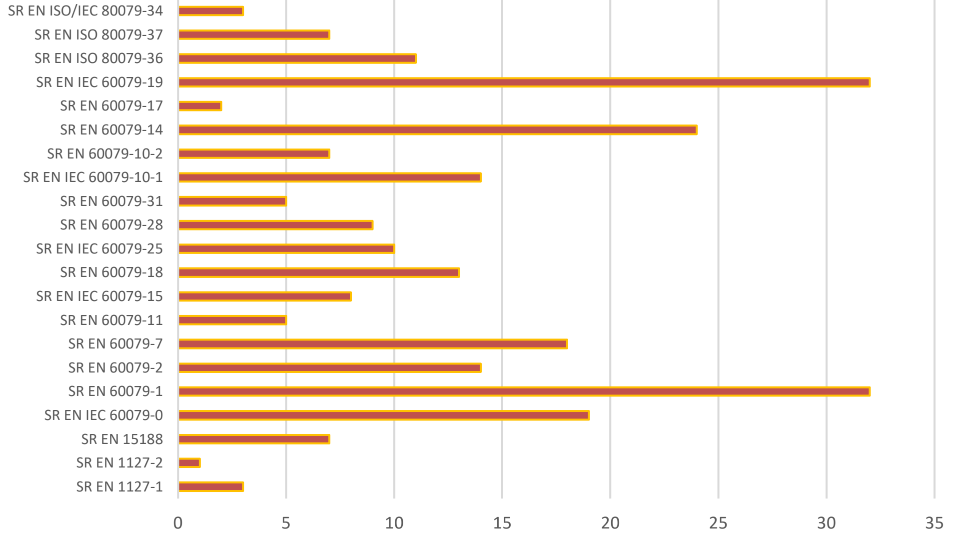

Fig. 3. The number of extensions.

The diagram in Figure 4 shows the number of major technical changes to the standards in the family of standards governing explosion protection. Thus, it can be seen that a significant difference is presented by the standard SR EN IEC 60079-15:2019 for protection type "n" for which a certain part of its body has been transferred to the standards of the protection types with which it correlates from the point of view of explosion protection.

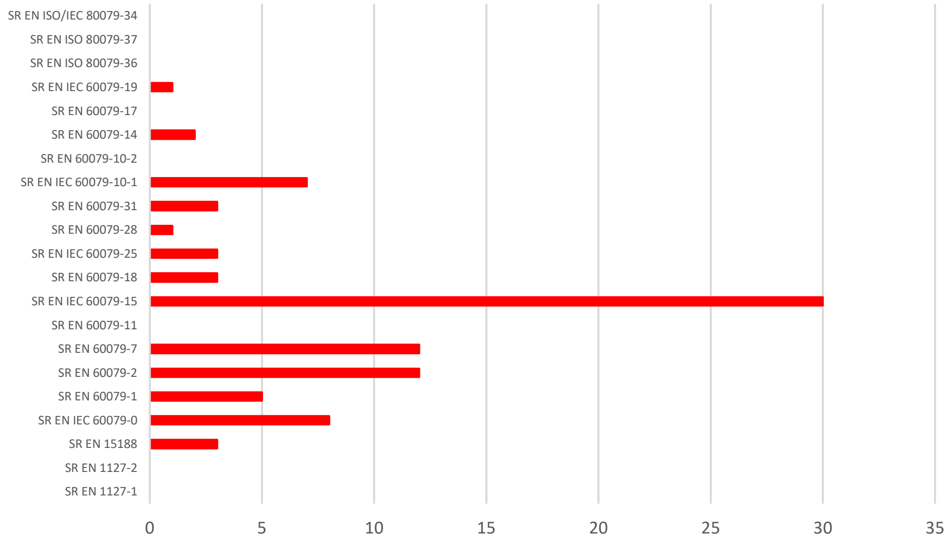

Fig. 4. The number of major changes.

Conclusions

A trend observed with the process of modernization of standards is that of increasing the complexity of existing technical solutions, as a result of the need to increase regulatory precision by highlighting more concrete application situations and technical possibilities for implementation, as well as introducing new technical solutions for explosion protection.

The number of minor changes in a standard highlights the increased focus on the standard so that it can be indirectly deduced that a standard with a higher number of minor changes is more widely used than a standard with a lower number of minor changes.

The number of extensions applied to the edition of the standard highlights both a need to adapt its requirements to current technical realities and also the evolution of the technique which for the context of the standard has led to these variations.

The number of major changes that an edition of a standard undergoes during its lifetime highlights paradigm shifts in its scope.

The set of standards considered in this paper covers both technical aspects concerning explosion protection (most of them) and aspects concerning the practical implementation of installations based on equipment protected with these types of protection. Another category covered by these standards is the area of quality assurance for equipment manufacturers, together with aspects relating to the competence of personnel involved in the design and manufacture of equipment and the design, assembly, use and maintenance of installations intended for use in potentially explosive atmospheres.

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