Computer application for facilitating the choice of Ex equipment

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Abstract. If electrical and non-electrical equipment used in underground mines susceptible to firedamp and coal dust or in other industries with explosion hazard is not proper selected for operating in explosive atmospheres, they are likely to generate an ignition of the atmosphere and to result in events with significant environmental and material damages and, moreover, with human victims. Therefore, it is mandatory for the responsible persons to reach the best decision when choosing the equipment which is suitable for operation in such atmospheres, from the explosion protection point of view. The current paper presents the development and operation of a Windows application for facilitating the choice of proper Ex equipment, in accordance with the specificity of the explosive atmosphere, whether there are involved the underground parts of the mines or the parts of the surface installations of these mines which could be endangered by firedamp gas/combustible dust, or other surface locations with explosion hazard

1 Introduction

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.

These can include many of the raw materials, intermediate products, final products and waste from the normal production process [1]. As explosions can cause human casualties and immeasurable property damage, the assessment of the risk of explosion and the establishment of appropriate 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 persons and property [2-3].

The objective of the paper is represented by the development of an IT solution to support the decision-making process for the installation of electrical [4] and non-electrical equipment for use in the underground parts of the mines and in those parts of the surface installations of these mines that may be exposed to firedamp and / or combustible dust, as well as those intended for use in other places with potentially explosive atmosphere

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2 Materials and methods

2.1 Groups and categories

EU legislation in force defines several categories and groups of equipment. The new standards in the protection to explosion field divided Group II of equipment used for non-mining industries with explosion hazard, into Group II for gases/vapours/mists and Group III designed for flammable dusts or powders in air [4-6]. The new classification based on the new equipment groups and categories is presented in the following:

- Group I apparatus: this group contains apparatus supposed to be used in the underground sectors of mine units or within the associated installations from the surface which are likely to be subjected to firedamp and/or combustible powders:
  - Category M1: it comprises devices designed and equipped with various additional protection measures (if required) in order to be able to operate in compliance with the functional parameters set out by the manufacturer. Such equipment has to ensure a very high protection level.
  - Category M2: it comprises devices designed to operate in compliance with the functional parameters set out by the manufacturer, ensuring a high protection level.
- Group II apparatus: this group contains apparatus supposed to be used in industries with explosion danger caused by burnable gases/vapors/mists, excluding the ones set out in Group I:
  - Category 1: this category contains devices built for operation in accordance with the functional specifications initiated by the producer. Such devices must ensure a very high protection level. Also, in case of occasional incidents, devices in category 1 must provide the proper protection level. In addition, they must dispose of protections so that:
    - if a type of protection is faulty, at least one additional autonomous type of protection has to assure the required level of protection, or
    - the required level of protection in case of two faults, which do not depend on each other, is ensured.
  - Category 2: this category contains devices built for operation in accordance with the purposeful specifications initiated by the producer. Such devices must ensure a high level of protection and they are supposed to be used in atmospheres with explosion danger caused by burnable gases/vapours/mists which may occur occasionally.
  - Category 3: this category contains devices which are supposed to be used in atmospheres which are not endangered by the occurrence of explosive atmospheres. Nonetheless, if explosive atmospheres occur, it happens very seldom and they do not last for long time periods.
- Group III apparatus: the third group comprises apparatus supposed to be used in atmospheres with explosion hazard generated by burnable dusts and powders, other than the ones set out in Group I. For apparatus in this group, classification in categories applies as presented before for Group II apparatus.

2.2 Hazardous area classification

Potentially explosive atmospheres are classified depending on the frequency and duration of the explosive atmosphere [5]. In case of an explosive gas atmosphere, hazardous areas are classified into zones based on an assessment of the frequency of occurrence and

duration of an explosive gas atmosphere [7-8]. The definitions found within regulations in force are:

Zone 0 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently

Zone 1 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally

Zone 2 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

In case of hazardous areas generated by combustible dusts, standards in force define the following three zones [9]:

Zone 20 - place where an explosive atmosphere of dust in the form of a cloud of dust in the air is present continuously or for long periods of time or frequently.

Zone 21- place where an explosive atmosphere of dust in the form of a cloud of dust in the air is likely to occur occasionally during normal operation.

Zone 22 - place where an explosive atmosphere of dust in the form of a cloud of dust in the air is not likely to occur during normal operation, but which, if it occurs, will persist only for a short period of time.

For the classification of industrial spaces with hazard of combustible dust (powder), a concept similar to that used for flammable gases and vapors is adopted in order to provide an indication of the risk of fire and / or explosion if there is a source of ignition. At the same time, unlike flammable gases and vapors, combustible dust will not necessarily be evacuated by ventilation or diffusion after the release has been stopped. This has implications for the classification of areas, which is different from that for flammable gases and vapors. If dust clouds are generated continuously or over long periods of time, very diluted and therefore non-explosive, thick layers of dust form over time. Starting from these layers of dust, rapid air movements can generate clouds of dust, creating explosive dust / air mixtures. A smoldering dust deposit, if disturbed, can ignite the dust cloud as a result.

2.3 Considerations on types of explosion protection

A type of protection to explosion is represented by the specific measures which are applied to the equipment so that to avoid a possible ignition of a surrounding explosive atmosphere. From the construction point of view, technical equipment supposed to be used in atmospheres with explosion danger may dispose of several types of protection These types of protection are specified by the equipment manufacturer in the Ex labelling, and are set out in accordance with the requirements of the applicable standards [10-16].

The reaching decision persons must choose the correct types of protection so that to install the electrical equipment in explosive atmospheres generated by flammable gases/vapours/mists properly, and they have to dispose of very good knowledge concerning the applicable methods of explosion protection.

2.4 Computer application development

Following the analysis of the technical and safety requirements to be met by the equipment in the installations operating in potentially explosive atmospheres, both in the underground mines with danger of firedamp atmosphere and / or combustible dust, and in other places with potentially explosive atmospheres, the logic diagram of the IT solution was developed, in order to facilitate the choice of electrical / non-electrical equipment intended for use in

explosive atmospheres (underground and surface), the application being named ExMark - Fig. 1.

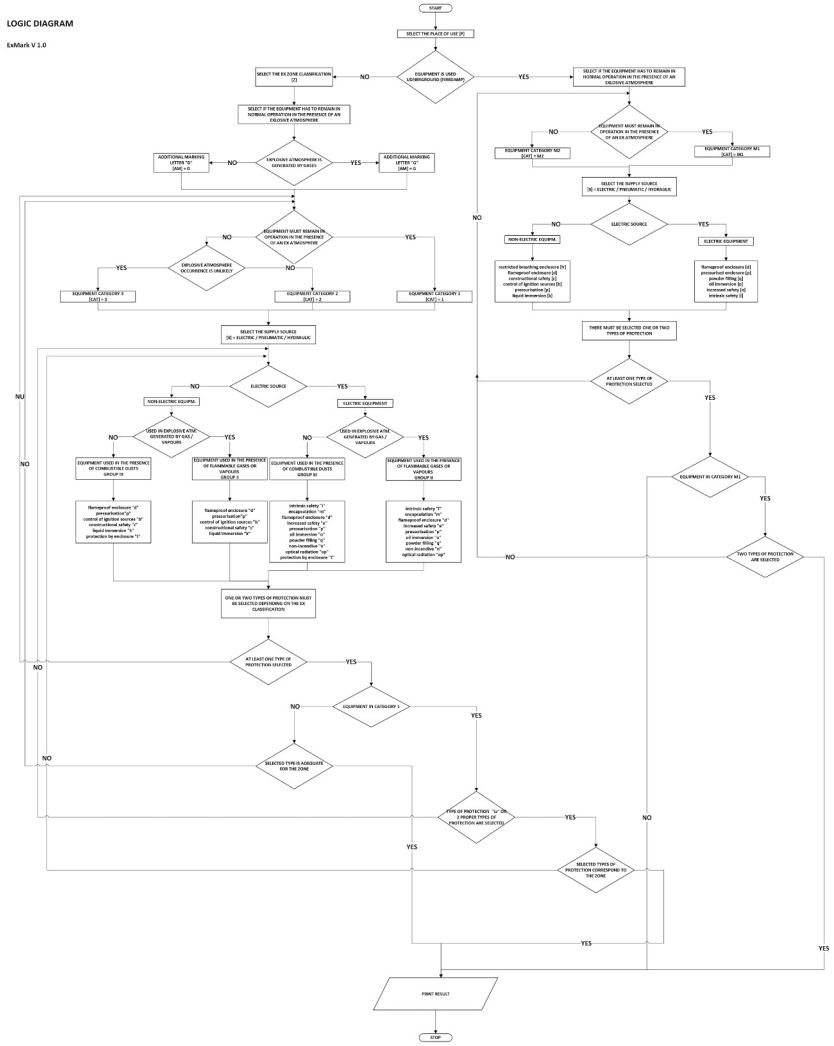

Fig. 1. Logic diagram.

The ExMark software application is a reasoning created to find the best and fastest solutions for selecting the right equipment according to the safety and protection to explosion requirements. It is developed in the C # programming language [17] and uses the .NET 4.8 framework, running on the Windows 11 operating system, both 64-bit and 32-bit.

The .NET framework is designed with a deep integration of standards and protocols used in the Internet, such as XML (Extensible Markup Language) and SOAP (Simple

Object Access Protocol) [18]. This greatly shortens the application design cycle. The .NET platform is one that can be both low-level, high-performance and easy to portability, and high-level to allow the use of all advanced programming concepts (objects, services, security, etc.). C # is an object-oriented programming language that is used primarily for the development of desktop, mobile, and web-based applications for Windows and other Microsoft products. By using the .NET framework, almost anything can be developed for Microsoft with C #.

3 Results and discussion

The developed computer application is based on a complex algorithm that depends on the input data related to the name of the equipment, the place of use (underground or surface), the Ex classification of the area (if applicable) and offers the possibility to select very important parameters regarding need for normal operation of the equipment in the explosive atmosphere and the choice of the appropriate types of explosion protection.

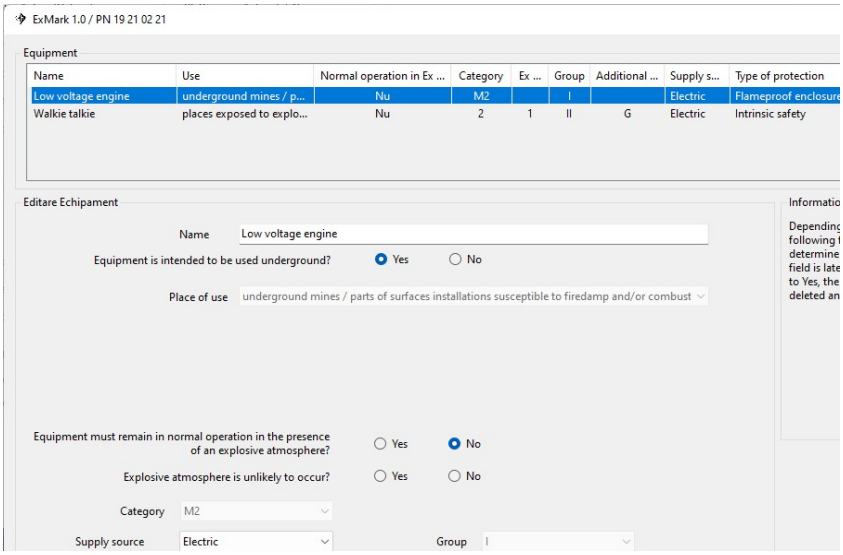

Fig. 2. Computer interface when inserting new equipment (used in firedamp mines).

The user interface looks nice, it's easy to use by any operator. In the home screen, the input data, which is the name, destination or place of use of the equipment, the data on the need of the equipment to operate in an explosive environment, the nature of the power source and the type or types of explosion protection, must be carefully entered. An important parameter is the nature of the type of energy with which the equipment is operated, depending on the selection made on this parameter, the algorithm generating explosion protection types for electrical and non-electrical equipment used in underground mines or other places with potentially explosive atmospheres. Depending on the selection of the location (of the explosive atmosphere) for which the equipment is intended, the computer application interface is populated with different fields for entering the relevant input data (for equipment used in mines - Fig. 2 / for equipment used in other places with explosive atmosphere - Fig. 3).

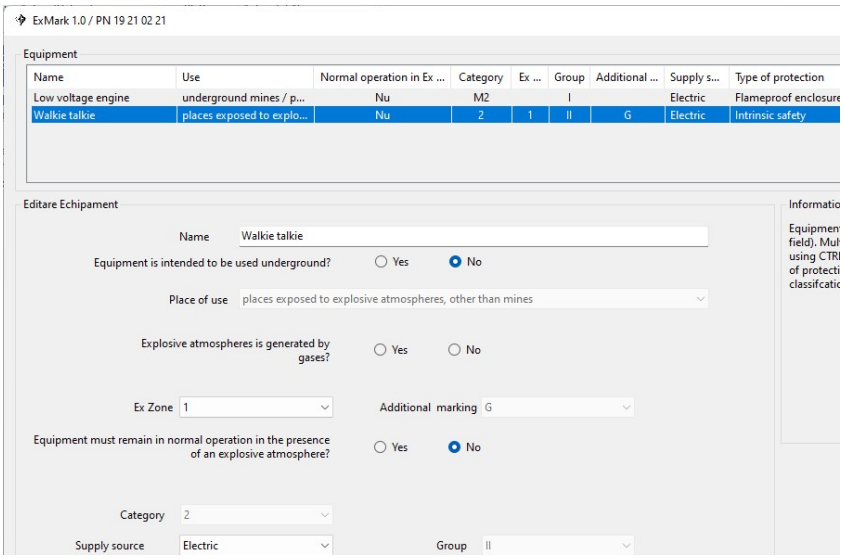

Fig. 3. Computer interface when inserting new equipment (used in other Ex atmospheres).

After entering the correct input data required to perform the selection process, the computer will display in a report that the equipment is suitable in terms of explosion protection to operate in explosive atmospheres (underground - Fig. 4 / surface - Fig. 5), as well as how to mark it in accordance with the requirements of Directive 2014/34/EU - Equipment used in potentially explosive atmospheres (ATEX) and applicable standards.

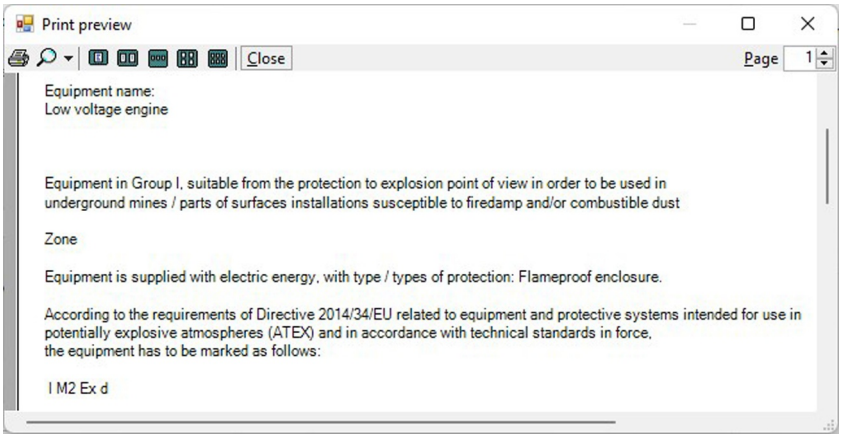

Fig. 4. Example of report generated for Ex equipment used in underground mines with firedamp and / or combustible dust atmospheres (Group I).

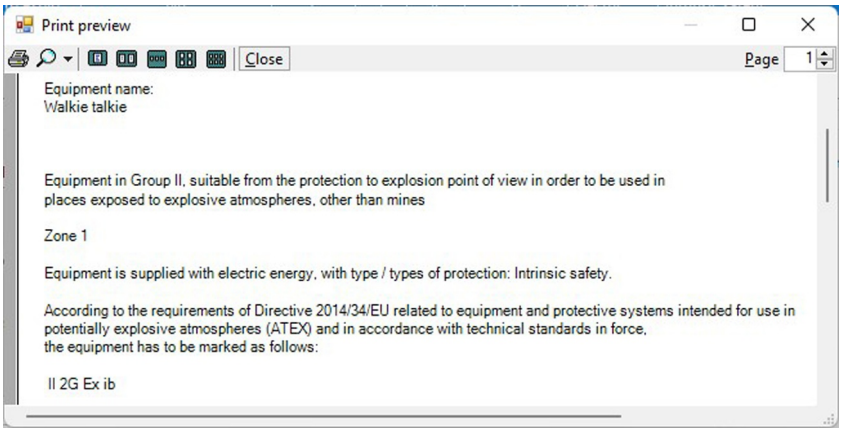

Fig. 5 Example of report generated for Ex equipment used in other Ex atmospheres (Group II/III).

4 Conclusions

ExMark software represents a useful tool for technical staff operating in companies dealing with the design, exploitation, maintenance and operation of equipment or installations from areas with explosion hazard generated by flammable gases, liquids, vapors, mists or dusts.

The main innovative characteristic of the developed IT application is that it transposes into a computer application, the various operations which have to be performed by responsible persons when selecting explosion-proof equipment intended to be installed and operated within explosive atmospheres from the underground parts of mines and in those parts of the surface installations of these mines which may be exposed to firedamp and / or combustible dust or the ones operating in other explosive atmospheres generated by flammable gases, vapors, mists or dusts. Using the developed Windows application, technicians dispose of quality, fast and reliable solutions for choosing the proper equipment which is going to operate in explosive atmospheres, in compliance with the safety and protection to explosion requirements in force, thus achieving an increased occupational health and safety level in industries with explosion hazard. Also, an important output information which is made available to them refers to the Ex label which has to be applied to the equipment in discussion.

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