

The choice of equipment for automation of hazardous production facilities

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Abstract. The characteristics that must be considered when selecting electrical equipment used at hazardous production facilities are discussed. To minimize hardware costs and security features it is suggested to use expert system based on the productional model.

1. Introduction

A large share of enterprises in various sectors of the economy refers to dangerous industrial objects. Most of them belong to the dangerous industrial objects from the point of view of explosion produced, used, processed, stored, transported and slaughtered flammable and combustible substances. The range of such enterprises is much wider than it seems. In addition to the classic dangerous industrial objects, such as coal mines, oil refineries, pumping stations, gas and oil objects and so on, it also includes, for example, painting chambers of machine-building enterprises, flammable liquids warehouses (flammable liquids) and even granary.

Automation of such objects must be secured from the standpoint of eliminating the potential of applied electrical equipment to become a source of initiation of explosion or fire. However, it should be noted that the higher the level of explosion-proof electrical equipment, the more expensive it is. Therefore, in the general case, the task of selecting the equipment is reduced to the minimization of the cost of equipment subject to constraints imposed by the need of security.

2. Classification of hazardous areas

Classification of hazardous areas is used for equipment selection by its protection level, ensuring safe operation of such equipment in the appropriate hazardous area. Dangerous industrial objects can have explosive zones of different classes, including explosion-proof zone. The class of hazardous areas is determined by the technologists together with the specialists of the design or operating organization. According to GOST R 51330.9-99 (IEC 60079-10-95) classification of hazardous areas should be undertaken by personnel who are familiar with the properties of combustible gases and vapors, knowledgeable technological process and equipment, in cooperation with safety engineers, electricians and other technical personnel [1].

Nowadays in the Russian Federation hardware for operation in explosive environments requirements are established by Technical regulations of the Customs Union "On safety equipment for working in hazardous environments" (TR TS 012/2011), which entered into force on February 15, 2013.

According to TP TC 012/2011 for explosive gas atmospheres (mixtures of flammable gases or vapours with air) hazardous zones are divided into three classes (see Fig.1):



- zone of class 0 is an area in which an explosive gas mixture is present continuously or for long periods of time;
- zone of class 1 is an area in which there is a probability of explosive gas mixtures under normal operating conditions;
- zone of class 2 is an area in which there is an unlikely presence of explosive gas mixtures under normal operating conditions, and if it does present, then it takes place rarely, and it is for a very short period of time.

For explosive dust environments the following classes of hazardous zone present:

- zone of class 20 is the area in which combustible dust, as a cloud, is present continuously or partially under normal operation in quantities capable of producing a concentration sufficient to explosion of combustible or inflammable dust / air mixtures, and/or where layers of dust arbitrary or excessive thickness can be formed;
- zone of class 21 is the area not classified as zone class 20, in which combustible dust is in the form of clouds may not be present under normal operation in quantities capable of producing a concentration sufficient to explosion of combustible dust in mixture with air;
- zone of class 22 is the area not classified as zone class 21, in which a cloud of combustible dust may occur rarely and is only stored for a short period or in which the accumulation of layers of combustible dust may occur when an abnormal operation mode, which can lead to the emergence able to ignite mixtures of dust in the air. If on the basis of abnormal conditions the elimination of savings or dust layers cannot be guaranteed, then the area is classified as zone class 21.

Separate classification of zones for gases and dust is explained by the fact that unlike zones for gas or vapors, flammable liquids, areas prone to ignition of combustible dust may be classified depending on the normal or emergency conditions and from time to time. Enhanced ventilation can cause clouds of dust and, respectively, increase but not reduce the risk [2].

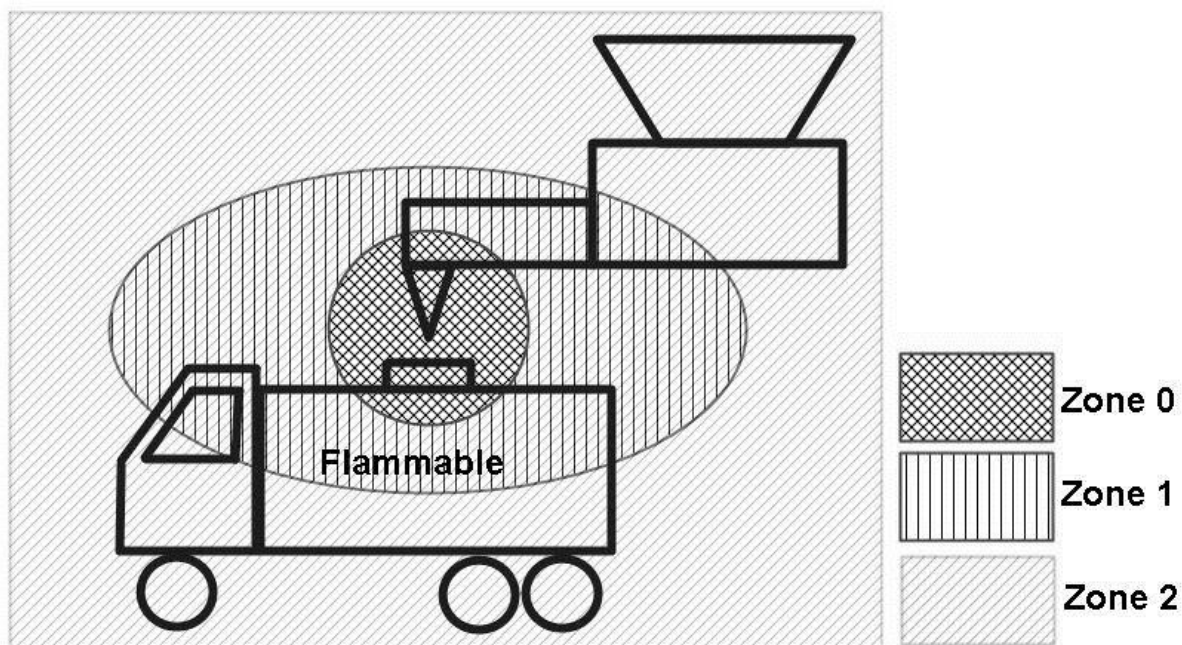


Figure 1. An example of hazardous zones distribution

Nowadays in Russia there are several series of standards and rules governing the use of explosion-proof equipment. For example, according to Chapter 7.3 “Rules for electrical installation” (REI) there is a different classification of hazardous areas for mixtures of gases and vapours with air:

- zone of class B-I is a zone located in the premises in which flammable gases and vapours of flammable liquids are emitted in such amount and with such properties that they can form with air an explosive mixture during normal operation modes, for example, when loading or unloading technological devices;

- zone of class B-Ia is a zone located in the room in which under normal operation a potentially explosive mixtures of flammable gases or flammable liquids or steam with air are not formed, but possible only during accidents or malfunctions;

- zone of class B-Ib is a zone located in the room in which under normal operation a potentially explosive mixtures of flammable gases or vapors, flammable liquids with air are not formed, but possible only during accidents or malfunctions, and which have some special features listed in paragraph (7.3.42 REI);

- zone of class B-Ig are spaces in outdoor installations: process units containing flammable gases or flammable liquids, ramps for unloading and loading of flammable liquids, etc.

Thus, for explosive mixtures of gases or vapours with air TR TC 012/2011 establishes three classes of zones, and REI – four, so formal correspondence between the two classifications cannot be set.

It should be noted that zone of class B-1a and B-1b can not be defined as zone 2, since the possibility of occurrence of failure from a legal perspective is not defined as frequency of occurrence and duration of an explosive mixture. However, for zones of class B-1a and B-1b it is necessary to use equipment designed for use at least in the zone 2 (equipment reliability against explosion).

To avoid error in the determination of compliance zones, equipment for zones of class B-Ig must have class explosion-proof corresponding to zone 1 (explosion proof equipment).

In zone B-I, in which an explosive gas mixture is present continuously or for long periods of time, it is possible to use equipment designed for operation only in zone 0 (explosion-proof equipment).

3. The choice of equipment

Explosion-proof electrical equipment is divided into groups:

I – equipment intended for use in underground mines and their surface structures, hazardous mine gas and/or combustible dust (mine explosion-proof electrical equipment). Depending on the design, the equipment of group I can have one of three levels of protection.

II – equipment intended for use in places (except underground mines and surface structures), with hazardous explosive gas environments. Depending on the design, the equipment of group II may have one of three levels of protection. Equipment of group II may be divided into subgroups depending on the category of explosive mixture, for which it is intended (IIA, IIB, IIC). For example, the subgroup IIA include methane, propane, subgroup IIB – ethylene, subgroup IIC – hydrogen, acetylene.

III – equipment intended for use in places (except underground mines and surface structures) with hazardous explosive dust environments. Depending on the design, the equipment of group III can have one of three levels of protection. Equipment of group III may be divided into subgroups depending on the characteristics of the explosive atmosphere for which it is intended (IIIA, IIIB, IIIC).

Explosion-proof electrical equipment, depending on the danger of becoming a source of ignition and conditions of its application in explosive environments, can be classified by levels of protection:

- 1) especially explosion-proof equipment (very high level);
- 2) explosion-proof equipment (high level);
- 3) equipment of high reliability against explosion (advanced level).

Depending on the maximum surface temperature, electrical equipment of group II is divided into temperature classes:

- 1) T1 – 450 °C;
- 2) T2 – 300 °C;
- 3) T3 – 200 °C;
- 4) T4 – 135 °C;
- 5) T5 – 100 °C;
- 6) T6 – 85 °C.

Depending on the envisaged special measures to prevent the ignition of a surrounding environment, the equipment may have one or a combination of several types of protection, for example:

- Explosion protection of type “i” with levels “ia”, “ib”, “ic” (spark-safe circuit);
 - Explosion protection of type “d” (flameproof enclosure);
 - Explosion protection of type “s” (special kind of protection);
- etc.

Example of marking of explosion-proof electrical equipment:

0ExiaIIBT3 – especially explosion-proof equipment with type of protection spark-safe circuit of level “ia”, for explosive gas group IIB with an ignition temperature of not less than 200 °C.

The choice of equipment for automation of dangerous industrial objects (from the point of view of explosion) should include the following steps:

- 1) Defining the group of electrical equipment depending on the scope (I, II or III).
- 2) Defining the class of hazardous zones in accordance with technical passport of a hazardous production facility, project or operational documentation. Depending on the class of hazardous areas and conditions of use of the equipment, the level of protection equipment is chosen.
- 3) Identifying subgroups of equipment depending on the energy of the ignition of explosive atmospheres (explosive composition of the mixture) in the labeling follows the type of protection;
- 4) Determining the type of protection equipment. It is necessary to consider the following:
 - different types of protection are characterized by different costs of operation;
 - not all levels of protection can be implemented by any type of protection. So, for example, especially explosion-proof equipment may not be realized by the application of protection type “flameproof enclosure” (protection type “d”)
- 5) Determining the temperature class of the equipment (marking follows a group of electrical equipment) according to the temperature of ignition of an explosive mixture.

The choice of the necessary equipment for the automation of a hazardous production facility requires highly skilled personnel, because the wrong choice can lead to incidents and accidents. One of the solutions to simplify the choice of equipment is the use of an expert system based on the production model. At each step rule-based models are used, allowing to represent knowledge in the form of “If (condition), then (action)”. Under “condition” some sentence-pattern is realized in accordance to which the search in the knowledge base is carried out, and under “action” the action is realized at the successful outcome of the search [3].

Example of rules usage when choosing equipment:

If the equipment is intended for use in places (except underground mines and surface structures), hazardous explosive gas environments, and if the equipment is intended for use in zone 0, and if an explosive mixture is classified as IIB, and if the explosion protection of the equipment necessary to provide a form of “spark-safe circuit”, and if the auto-ignition temperature explosive mixture is at least 200 °C and 300 °C, then the equipment must be selected by marking 0ExiaIIBT3.

4. Conclusion

Application of expert system in the selection of electrical equipment for use in hazardous production facilities will allow, on the one hand, to reduce the risk of accidents due to the exclusion of incorrect equipment selection, on the other hand, to optimize the cost of the equipment used.

References

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