ASPECTS REGARDING USEAGE OF THE HIGH VOLTAGE SOURCE IN ORDER TO VERIFY THE INSULATION SYSTEMS OF ELECTRIC MOTORS WITH THE TYPE OF PROTECTION INCREASED SAFETY USED IN POTENTIALLY EXPLOSIVE ATMOSPHERE

DRAGOȘ FOTĂU[1], ANCA ALEXANDRA TĂZLAUANU[2], SORIN ZSIDO[3]

Abstract: Evaluation of explosion-proof protected electrical equipment in scope of certification is extremely important considering the risk of explosion that has to be minimized in order to ensure life safety and health of workers and to prevent damaging of property and the environment, as well as free movement of goods when they meet the essential safety requirements at European level. Due to the fact that electric motors with type of protection Increased Safety, whose supply voltage exceeds 1000 V, presents a high risk of sparks occurring in windings, it is necessary to perform tests to verify that the insulation of the windings is adequate and does not lead to electric discharge (through electric springs or sparks) at winding levels. A very important test by which these aspects are verified is the overvoltage-ignition test, applicable to electric motors with increased safety protection type.

Keywords: electric equipment, increased safety, certification, explosive atmosphere.

1. INTRODUCTION

Explosive atmospheres can occur in various industrial fields, in installations in which flammable substances are processed, transferred or stored.

Using electric energy in potentially explosive atmospheres brings forward several particularities therefore the problems that appear during the design, construction and operation of electrical devices and installations brings forward numerous difficulties, their approach requiring special attention considering all the technical, economical and labour safety aspects [1], [5].

The risk of explosion may appear in all the fields of activity in which flammable substances are involved, such as gases, vapours, dusts, mists, which mixed with air may result in potentially explosive atmospheres [5].

[1] *Sc. Res. I[s], PhD.Eng., INCD INSEMEX Petrosani, dragos.fotau@insemex.ro*
[2] *Stud. Eng., INCD INSEMEX Petrosani, anca.tazlauanu@insemex.ro*
[3] *Eng., INCD-INSEMEX Petroșani, sorin.zsido@insemex.ro*

To prevent the ignition of explosive atmospheres, the electrical equipment used in such areas must be made with different types of protection so that it can not ignite the explosive mixture surrounding the electrical equipment [1], [4].

The type of protection means the specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere [2].

For each type of protection applied to electrical equipment used in potentially explosive atmosphere, a wide range of type tests have been developed so that they can be used safely [2].

The evaluation of explosion-protected electrical equipment with type of protection increased safety is carried out by means of tests and verifications performed on the basis of the reference standards (SR EN 60079-0 - which includes the general requirements for all explosion-protected electrical equipment and the standards specific to the types of protection involved in the manufacture of the equipment). In the case of increased safety protection type, the specific standard is SR EN 60079-7 [2], [3], [6].

In order to verify explosion protection, the representative samples made available by explosion-protected equipment manufacturers are tested under the most unfavourable conditions that may occur in operation.

Most of the equipment used in technical installations in potentially explosive atmospheres (refineries, fuel depots, gas stations, dyestuffs, etc.) are electric motors, which in most situations act on various other elements.

2. ELECTRICAL TESTS CARRIED OUT ON ELECTRIC MOTORS WITH TYPE OF PROTECTION INCREASED SAFETY

The "e" increased safety type of protection implies equipment that does not produce electric arcs, sparks or excessive temperatures on any of the interior or exterior parts of the equipment, because of that it is necessary that these phenomena to be avoided [3], [7].

Because electric motors with increased safety type of protection (eb), whose supply voltage exceeds 1000 V, pose a high risk of sparks occurring in windings (due to the choice of an inadequate method of winding insulation), it is necessary to perform tests to verify that winding insulation is adequate and does not lead to electric discharge (by electric arcs or sparks) at winding levels [7].

This sparking risk in the winding occurs at weak insulation spots when the charge in the weak spot becomes too high. This weak spot is excessively stressed during the operation of the electric motor or during the high-voltage test. This weak spot cannot resist this increased stress. As a result there is a partial breakdown in this location. This partial breakdown is referred to as partial discharge. However, the remaining insulation can still resist the increased voltage stress so that there is not a complete breakdown [4], [9].

The tests by which these aspects are tested are the impulse ignition test and the overvoltage-ignition test, applicable to electric motors with type of protection increased safety.

Insulation systems and connecting cables shall be tested in an explosive test mixture as presented in Table 1. They shall be subjected to 10 voltage impulses of not less than three times peak phase to earth voltage and with a voltage rise time between

0,2 μs and 0,5 μs and with a time to half value which is at least. No ignition of the explosive test mixture shall occur [7].

Insulation systems and connection cables shall be tested in an explosive test mixture, with a sinusoidal voltage of at least 1.5 times the rated r.m.s. line voltage for at least 3 min. The maximum rate of voltage rise shall be 0.5 kV/s. The voltage shall be applied between one phase and earth with the other phases earthed. No ignition of the explosive test mixture shall occur [3], [8].

Table 1. ***Explosion test mixtures***

Equipment group	**Test mixture in air v/v**
II C	(21 ± 5) % hydrogen
II B	(7.8 ± 1) % ethylene
II A	(5.25 ± 0.5) % propane

3. USE OF THE HIGH VOLTAGE SOURCE IN ORDER TO VERIFY THE INSULATION SYSTEMS OF ELECTRIC

Within our laboratories were performed overvoltage-ignition test for stator insulation systems on electric motors used in potentially explosive atmosphere, as exemplified in Figure 1.

Fig.1. Insulation system subjected to overvoltage test in explosive mixtures

To carry out these tests were used specific testing equipment like: Oxygen analyser SERVOMEX 2200, high voltage source Sefelec. The tests were carried out with an explosive mixture whose characteristics correspond to the requirements (concentration 22 % hydrogen, test temperature 22°C).

Fig.2. High voltage source Sefelec used to test the insulation systems of electric motor

Pre-start purge may be adopted for Ex e, N or n motors at risk of incendive sparking, and is designed to purge clean air through the motor enclosure to remove any residual potentially flammable gas. Its purpose is to prevent the risk of explosions due to rotor sparking during starting; air flow sensors and pre-start timers may monitor this purge process before allowing the application of the HV electrical supply, or control may be achieved by procedures. Once the motor is started, no further pre-purge flow is provided [8].

A suitable purge connection point should be provided by the manufacturer. The purge gas supply is provided by the user, from a fixed supply or from portable gas bottles. (Nitrogen is sometimes used instead of using clean air) [6, 11].

Fig.3a. High voltage sources display (during test)

Ignition risks owing to stator sparking may also occur when the motor is running; this phenomenon has only been acknowledged relatively recently.

Note that pre-start purge does not offer any protection, but suitable special measure might be to pressurise the motor enclosure continuously in order to prevent the ingress of a potentially flammable atmosphere; this arrangement should be interlocked with pre-start and post shut-down timers and pressure/flow measurement, but may not fully comply with the standard for Ex p apparatus [6].

After performing the test in explosive mixtures, it turned out that the windings of the motor correspond to the requirements of the type of protection increased safety. (Fig. 3a, Fig. 3b)

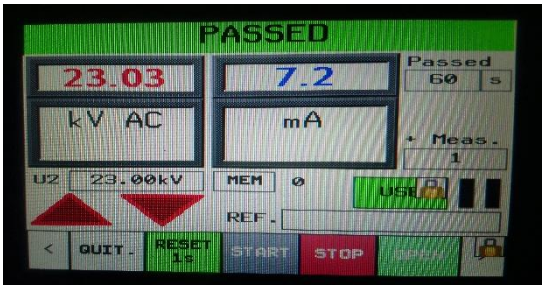

Fig.3b. High voltage sources display (the test has been completed)

4. CONCLUSIONS

In this paper was revealed the importance of the tests carried out on electric motors used in potentially explosive atmosphere and the aspects that should be considered when starting the motors. The modernization of the test stands will lead to the increase of the quality of the tests, finally resulting in an increased level of safety and health at work for the workers who operate in the industries with danger of explosive atmosphere.

With the high voltage source which we purchased last year we can perform more accurate tests, in explosive mixtures. This way we have increased the testing capacity of the laboratory and we increase the quality of the tests.

Medium voltage electric motors with increased safety type of protection present a fairly high risk of explosion, also because of the sparking phenomenon that can occur in the stator windings (including partial discharges). These phenomena shall be avoided by the construction of the motor and especially of the insulation system of the stator winding. Motors with type of protection increased safety “eb” can work in zone 1, and when the motor is stopped, inside the housing explosive mixture may enter. When starting the motor, overvoltage can be generated, much higher than the rated voltage, and if windings are not properly insulated, sparking may occur. For this reason it is important that the motors are tested in accordance with the requirements in force.

To prevent the risk of explosions due to rotor sparking during starting the motor can be purge with clean air or with a gas which is not explosive as it is done on the pressurised electric motors.

In this paper was revealed the importance of the tests carried out on electric motors used in potentially explosive atmosphere and the aspects that should be considered when starting the motors. The modernization of the test stands will lead to the increase of the quality of the tests, finally resulting in an increased level of safety and health at work for the workers who operate in the industries with danger of explosive atmosphere.

In order to protect people who work in explosive environments, it is important that equipment operating in such areas to comply with the requirements in force, and be properly maintained by personnel who know the principles of explosion protection.

REFERENCES

[1]. ATEX Directive, *Equipment for potentially explosive atmospheres (ATEX)*, available https://ec.europa.eu/growth/sectors/mechanical-engineering/atex_en, 2014.

[2]. Dobra R., Buica G., Pasculescu D., Leba M., *Safety management diagnostic method regarding work cost accidents from electrical power installations*, Proceedings of the 1st International Conference on Industrial and Manufacturing Technologies, 2013.

[3]. Pasculescu D., Niculescu T., Pana L., *Uses of Matlab Software to size intrinsic safety barriers of the electric equipment intended for use in atmospheres with explosion hazard*, Proceedings of the International Conference on Energy and Environment Technologies and Equipment (EEETE '10), RECENT ADVANCES in ENERGY and ENVIRONMENT TECHNOLOGIES and EQUIPMENT, Bucharest, Romania, Aprilie 20-22, 2010.

[4]. Niculescu T., Pasculescu D., Pasculescu V.M., Stoica I.O., *Evaluation of electrical parameters of intrinsic safety barriers of the electrical equipment intended to be used in atmospheres with explosion hazard*, 14th International Multidisciplinary Scientific Geoconference SGEM 2014, GeoConference on Informatics, Geoinformatics and Remote Sensing, Conference Proceedings, Volume I, Section Informatics, Albena, Bulgaria, 17-26 June, 2014.

[5]. Popescu F.G., Păsculescu D., Păsculescu V.M., *Modern methods for analysis and reduction of current and voltage harmonics*, Editura LAP LAMBERT Academic Publishing, 2020.

[6]. Popescu F.G., Pasculescu D., Marcu M., Handra A. D., *The technical and economic advantages of power factor correction,* Annals of University of Petrosani, Electrical Engineering, Vol. 21, pag.35-42, Petroșani, 2019.

[7]. * Standard (SR) EN 60079-0 -** *Explosive atmospheres - Part 0: Equipment - General requirements.*

[8]. * Standard (SR) EN 60079-1 -** *Explosive atmospheres - Part 1: Equipment protection by flameproof enclosure "d", 2015.*

[9]. * Standard (SR) EN 60079-7 -** *Explosive atmospheres - Part 7: Equipment protection by increased safety "e", 2016.*

[10]. *** *Partial discharge test to evaluate windings of low-voltage electric motors with regard to frequency converter capability as well as general insulation strength, Partial discharge brochure.-https://library.e.abb.com/public/d35ed76b345b4f368192407106435eed/ABB%20whitepaper_Partial_discharge.pdf*

[11].*** *http://www.hse.gov.uk/offshore/infosheets/is3-2010.htm*