THE IMPORTANCE OF USING THE HIGH VOLTAGE PULSE GENERATOR IN THE CERTIFICATION PROCESS OF ELECTRIC MOTORS WITH THE TYPE OF PROTECTION INCREASED SAFETY USED IN POTENTIALLY EXPLOSIVE ATMOSPHERE

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Abstract. The purpose of this paper is to present the importance of the specific tests for electric motors with type of protection increased safety „e” designed to be used in explosive atmosphere.

This paper presents the voltage impulse ignition test applicable to electric motors with increased safety protection type.

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.

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.

The standard SR EN 60079-0 (Explosive atmospheres Part 0: General requirements) and one or more of the standards containing the specific requirements for the type(s) of protection applied to equipment (ex. SR EN 60079-7 for the type of protection increased safety "e"), are used to perform the assessment.

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1 Introduction

Using electric equipment 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 labor safety aspects. Due to this fact, it is very important that the equipment is properly tested during the certification process. [5]

Even if electric motors for explosive atmospheres are designed and manufactured following some of the same principles as the ones used for other electric machinery, they have certain particularities related to their field of use. Thus, a series of specific restrictions and tests are required to be considered in their case.

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], [8]

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]

In order to verify explosion protection, the representative samples made available by explosion-protected equipment manufacturers are tested under the most unfavorable conditions that may occur in operation [4]. [6], [10]

2 tests carried out on insulation sistem of an electric motor

Explosion-proof characteristics of electrical equipment, are assessed mainly according the provisions of harmonized standards from the SR EN 60079 series. The standards SR EN 60079-0 and one or more of the standards containing the specific requirements for the type(s) of protection applied to equipment (also from the SR EN 60079 series) are used for performing the assessment [2].

Most of the equipment operating in potentially explosive atmospheres (chemical compounds, refineries, fuel depots, dyestuffs, etc.) are electric motors, which in most situations act on various other elements (pumps, vibrating sites, conveyors, etc.).

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.

Electrical equipment and Ex Components of type of protection increased safety “e” are either: Level of Protection “eb” (EPL ‘Mb’ or ‘Gb’); or Level of Protection “ec” (EPL ‘Gc’) [3]

Level of Protection “eb” applies to connections, conductors, windings, lamps, and batteries; but not including semiconductors or electrolytic capacitors [3].

Level of protection “ec” applies to connections, conductors, windings, lamps, and batteries; including semiconductors or electrolytic capacitors.

Electric motors with type of protection increased safety usually works in zone 1, when the electric motor is stopped, inside the casing explosive mixture may enter. When starting the motor, overvoltage can be generated, much higher than the nominal voltage, and if windings are not properly insulated, sparking may occur between windings.

According to standardized requirements, in addition to the tests specified by SR EN 60079-0, the electric motors with type of protection increased safety are subject to additional specific tests (for electric motors) as specified in SR EN 60079-7: [3]
a) Determination of starting current ratio $I_A/ I_N$ and the time $t_E$

b) Mounting of machine for test

c) Stator winding insulation system (impulse ignition test for “eb” stator insulation systems and steady state ignition test for “eb” and “ec” stator insulation systems)

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 [6].

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 [7], [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 [3].

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 [3].

<table>
<thead>
<tr>
<th>Equipment group</th>
<th>Test mixture in air $v/v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>II C</td>
<td>$(21 \pm 5)%$ hydrogen</td>
</tr>
<tr>
<td>II B</td>
<td>$(7,8 \pm 1)%$ ethylene</td>
</tr>
<tr>
<td>II A</td>
<td>$(5,25 \pm 0,5)%$ propane</td>
</tr>
</tbody>
</table>

In the National Institute for Research and Development in Mine Safety and Protection to Explosion – laboratories were performed impulse ignition test for stator insulation systems on electric motors used in potentially explosive atmosphere. To carry out these tests were used specific testing equipment like: Oxygen analyser SERVOMEX 2200, Baker (Megger) Fig. 1, surge tester D12R, PP24 -impulse generator. The tests were carried out with an explosive mixture whose characteristics correspond to the requirements (concentration-22% hydrogen, test temperature - 22°C) [6]. 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. 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].

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[7].

Fig. 1. High voltage pulse generator

Fig. 2. Electric motor windings prepared to be tester in explosive mixtures
3 Conclusions

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. With the high voltage pulse generator we can perform more accurate tests, in explozive mixtures.

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.
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