

Research on the improvement of test methods for the determination of dust penetration in enclosures of equipment intended for explosive atmospheres

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Abstract. Carcasses of electrical or non-electrical equipment operating in potentially explosive atmospheres must provide a certain degree of protection against access to hazardous parts, penetration of solid bodies and/or water penetration, which must be tested according to the specifications of the Ex protection types. Normal protection classes are indicated by the international IP code followed by two characteristic digits referring to the protection against penetration of solid foreign bodies and water protection, followed by optional letters if required by the beneficiary according to the imposed conditions of use. Within the ENExEMEIP laboratory, have been developed laboratory tests to verify the first characteristic figure of the standard degree of protection according to the standardized European method. In the paper is presented the test stand of the large gauge equipment, a stand made with state-of-the-art equipment that provides the necessary performance for the accreditation of the test according to the standardized requirements. Checking dustproof protection to equipment used in areas where explosive atmospheres generated by combustion dust may occur is particularly important for assessing compliance with the requirements of the ATEX Directive [5], as this protection is a basic requirement for explosion protection.

1 Introduction

In industrial areas that process combustible substance may occur under normal working conditions due to accidental processes or spills, explosive mixtures of gases, vapours, mists, flammable liquids and / or combustible dusts and air.

In order to avoid all effective possible sources of explosive mixtures, it is important first of all to know them. The cause of the explosion trigger is the caloric energy given by the source of the explosive environment. The combustion intensity depends on numerous factors depending on the reaction rate between the oxygen and the fuel. Normal burning in open spaces or outbreaks, always accompanied by flame, is normal combustion.

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In most cases, combustible dusts are a fire hazard and mixed with air in certain concentrations and in the presence of a source of ignition and explosion hazard. The existence of this real danger was confirmed by the events that took place in economic units, for example: forage factories, textile industry, steel industry, etc.

Because in most cases fires and explosions cause damage with significant economic and social effects, it is absolutely necessary to take appropriate measures to prevent such a hazard.

To prevent the risk of explosion and / or fire, the essential security requirements are oriented in two directions [1, 2, 3]:

- preventing the formation of explosive atmospheres of gases, vapours, flammable liquids and / or combustible dust, and keeping its contents mixed with air below the limit value considered as non-hazardous.
- the limitation of ignition sources by the use of equipment and installations in which all electrical parts capable of producing sparks, springs or all parts having a temperature above the ignition temperature of the dust are protected or totally enclosed in caps or have electrical circuits limited.

This goal is achieved by meeting the requirements for avoiding or reducing the amount of explosive atmosphere by controlling process parameters and by designing and constructing equipment, protection systems and their components.

The analysis of the European standards reveals that they have a strong dynamic in relation to the European Directives, which requires the continuous improvement of the test methods specific to the various equipment.

2 Measures imposed on equipment intended for use in areas with combustible dust to reduce the risk of dust entering the enclosure

To ensure adequate security for equipment intended for use in hazardous areas, different explosion protection techniques should be applied.

Currently, "ignition protection by carcasses" is the most effective protection method for equipment intended for use in areas with combustible dust and is based on limiting the maximum surface temperature of the carcass and restricting the access of dust inside the equipment by using watertight equipment dust or dust-proof [1].

In order to be used safely, both electrical and non-electrical equipment must have a housing that provides a normal IP protection (international code) followed by two characteristic digits. In accordance with general standard SR EN 60079-0:2013/A1:2014, an electrical / non-electrical equipment must provide at least a degree of protection IP XX for a specific type of protection, the test procedures being in accordance with the requirements of SR EN 60529:1995/AC:2017 and in the case of rotating electric machines in accordance with SR EN 60034-5:2003/A1:2007 [4, 7].

If a specific digit is not required, it should be replaced by the letter "X" (or "XX" if both digits are omitted), e.g.: IP6X; IPX7; IPX6 / IPX8).

In practice, the following degrees of protection can be achieved, shown in Table 1:

Table 1 - Normal protection classes

The first characteristic figure (solid bodies)	The second characteristic figure (water)									
	0	1	2	3	4	5	6	7	8	9
0	IP00	-	-	-	-	-	-	-	-	-
1	IP10	IP11	IP12	-	-	-	-	-	-	-
2	IP20	IP21	IP22	IP23	-	-	-	-	-	-
3	IP30	IP31	IP32	IP33	IP34	-	-	-	-	-
4	IP40	IP41	IP42	IP43	IP44	-	-	-	-	-
5	IP50	-	-	-	IP54	IP55	-	-	-	-
6	IP60	-	-	-	-	IP65	IP66	IP67	IP68	IP69

Synthetically, attempts to determine the IP-specific digits for protection against the penetration of foreign solids (first characteristic figure), protection against moving parts inside or inside the equipment as well as protection against water penetration inside the equipment casing (the second characteristic figure) are shown in Table 2.

Table 2 – The elements of the IP code and their meanings

First characteristic figure		Second characteristic figure	
IP	Description	IP	Description
0	Unprotected	0	Unprotected
1	Protected against foreign solids with a diameter of 50 mm and above (protected against hand-to-hand access to dangerous parts)	1	Protected against drops of water falling vertically
2	Protected against foreign solids with a diameter of 12 mm and larger (protected against finger contact to dangerous parts)	2	Protected against vertical droplets of water that can be rotated at 15°
3	Protected against foreign solids with a diameter of 2.5 mm and higher (fine tools, wires)	3	Protected against sprayed water at an angle of up to 60° to the vertical
4	Protected against foreign solids with a diameter of 1 mm and higher (fine tools, wires)	4	Protected against sprayed water on all sides
		5	Protected against water jets on all sides
5	Protected against dust (against hazardous deposits)	6	Strong water jet, equivalent to sea waves during storm
6	Dust-tight	7	Protected against immersion in water
		8	Protected during permanent immersion in water (1000 mm)
		9	Protected against strong water jets (high pressure and high temperature)

3 Attempts to protect against partial or total dust ingress inside large equipment

Considering the need to test large dust protection equipment inside the casing, it was necessary to design and build a performance stand for their testing, presented in figures 1,2 and 3 [1, 7].



Fig. 1. Container isolated



Fig. 2. The dust chamber

The stand is composed of a heat-insulated bulkhead with a double hopper, vibrator and air injector, as well as a suspension particle recirculator which agitates the talcum powder and maintains it in suspension in a temperature-controlled environment, and pressure.

Both the vibrator and the air injection system are controlled by the PLC, the vibration times and air injection being precisely predetermined to ensure that the dust is brought into suspension and directed to the recirculation absorber wells.



Fig. 3. Command room with Flow Control / Pressure / Control Panel

For temperature control, a heating battery is placed on the talc recirculation system with PLC temperature control, which ensures temperature stability in the test chamber with an accuracy of $\pm 1^\circ\text{C}$ and drying of the talc powder suspended.

The dust recirculation system uses a special design turbine for solids recirculation, and the flow is controlled by the PLC by varying the supply voltage frequency to two preset values, one for heating and drying and the other for the test flow rate.

For the testing of equipment which is assumed to be in service (category 1 carcasses, eg electric motors, transformers, lighting fixtures, etc.), the requirements of the harmonized test standards are to extract 80 free interior volumes of the air in the tested equipment, but not exceeding a 60-hour extraction rate of the carcass volume.

To meet these conditions, a specialized software was developed and realised to control test parameters as follows:

- limiting the extraction pressure to a 200 mm water column;
- entering the extraction flow value according to the calculated calculation and automatic flow control.

Extraction flow control is performed by a PLC with frequency converter for supply voltage of the vacuum pump motor using flow sensors and pressure sensors. The sensors are interleaved on the extraction system, which feeds the computer and related software, the latter sending a PID signal to the PLC.

At the same time, the software also performs the logger function, recording the flow, pressure, temperature and time values for the test, and the data can be used to plot the test chart for the test report.

Finally, it can be said that the system is fully automated, making the test dependent only on introducing the test time into the software after a preliminary flow test, and then with the START button, the software will self-test and stop the equipment at end of the test.

The time records of the monitored parameters, monitored by the command, acquisition, processing and data recording software, are represented in the graph in Fig. 4.



Fig. 4. Variation in time of pressure, flow, and temperature

It is also possible to manually work in which the user can adjust any flow or pressure value, computer-readable and analogue reading, but without any software control. In this case, the user must test and count the test time, possibly make adjustments during the test, and stop the stand at the end of the test.

4 Conclusions

Laboratory tests to determine partial or total dust protection in large electrical and non-electrical equipment are of particular importance for assessing the conformity of equipment with the requirements of the harmonized European standards and the explosion protection requirements of the transposed Directive 2014/34 / EU [5] in Romanian legislation by GD 245/2016.

In order to perform these tests, in the laboratory of ENExEMEIP within INCD-INSEMEX Petroșani after the design of the technological scheme and elaboration of the specification, a dust test stand of the large equipment was purchased. This stand is equipped with high precision control and monitoring equipment, in accordance with the requirements of European standards, equipment that controls and monitors with high accuracy the required parameters and meets the requirements of SR EN ISO / CEI 17025:2005 / AC:2007 for competence and accreditation testing and calibration laboratories.

The development of testing methods within the testing laboratory contributes to the extension of the test capacity, offering the possibility to apply them to solve the demands of the producers, beneficiaries and / or inspection and market surveillance bodies.

The stand shall provide an adequate working environment and a level of safety and health appropriate to the personnel involved in the test and certification of electrical and non-electrical equipment intended for potentially explosive atmospheres.

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