Annals of the University of Petrosani, Electrical Engineering, 20 (2018)

EVALUATION OF ENCAPSULATED EQUIPMENT

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Abstract: This paper presents the explosion protection principles implemented for the type of protection encapsulation "m" which are based on the adoption of certain separations between the encapsulated circuits and the other circuits, by including them in a compound. The paper describes the test methodologies for explosion-proof electrical equipment with type of protection encapsulation "m".

The use of electrical energy in potentially explosive atmospheres involves various particularities, fact for which there have been raised a lot of issues concerning the design, construction and exploitation of electrical equipment and installations intended to be used in these atmospheres.

Keywords: type of protection, encapsulation, electrical equipment, compound, type test

1. GENERAL CONDITIONS

In health and security domain, it is noted a rising trend of the security level in conformity with scientific knowledge state and with taking in consideration of the new risk factors due to economic development. It also follows the same trend the protection of low currents installations utilized in workplaces with risk of explosives atmospheres. Directive 2014/34/EU states that equipment and installations utilized in explosive atmospheres must have compatible specifications with the ones of explosive atmosphere there are about to work.

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In order to evaluate the equipment for protection to explosion, encapsulation type, one has to follow an investigation process of the equipment in terms of its conformity with relevant standard requirements for protection to explosion. As to evaluate the electric equipment for protection to explosion, type encapsulation "m", the current trend is to increase the evaluation share through applicable calculus on the equipment, using tables and diagrams presented in applicable standards SR EN 60079-0; SR EN 60079-18. This paper follows the study and assessment of the requirements concerning absorption test for electric equipment with type "m" protection.

2. CONSIDERATIONS ABOUT THE ENCAPSULATED EQUIPMENT TESTS

The conformity assessment of technical documentation for equipment used in potentially explosive atmospheres is made in accordance with Directive 94/9/EC, annex 3. The documentation submitted to the notified body must include the following:

•a general type-description;

•design and manufacturing drawings and layouts of components, subassemblies, circuits, etc.;

•descriptions and explanations necessary for the understanding of said drawings and layouts and the operation of the product;

•a list of the standards referred to in Article 5, applied in full or in part, and descriptions of the solutions adopted to meet the essential requirements of the Directive where the standards referred to in Article 5 have not been applied;

•results of design calculations made, examinations carried out, etc.;

•tests reports.

The notified body shall:

•examine the technical documentation, verify that the type has been manufactured in conformity with the technical documentation and identify the elements which have been designed in accordance with the relevant provisions of the standards referred to in Article 5, as well as the components which have been designed without applying the relevant provisions of those standards;

•perform or have performed the appropriate examinations and necessary tests to check whether the solutions adopted by the manufacturer meet the essential requirements of the Directive where the standards referred to in Article 5 have not been applied;

•perform or have performed the appropriate examinations and necessary tests to check whether these have actually been applied, where the manufacturer has chosen to apply the relevant standards;

•agree with the applicant the location where the examinations and necessary tests shall be carried out.

Equipment/installations of low currents are those equipment / electrical installation in which the electric components utilized for info transfer, for mini-macro movements also for the components whose nominal voltage doesn't exceed 11 kV, are included in a compound.

A brief review on these protection type encapsulation installations following their objectives: equipment and installations in automation field, data communication, interlocks, controls; Monitoring and alarm equipment and installations for water leaks, explosive and toxic gases, respectively for fire; equipment and installations for access control, warning device for surveillance; equipment and installations for (video) intercom, telephony and sound; equipment and installations for data transmission and VDI; equipment and installations for data cable CATV and other circuit parts (Figure 1).

Fig. 1. Encapsulated equipment and electrical installations

The protection type in which the parts that can ignite an explosive atmosphere either by spark or by heating, are included in a compound, so that the given explosive atmosphere can't be lit in normal operating conditions is referred to as encapsulation "m".

The electric encapsulated "m" equipment can be with:

a) protection level "ma" (EPL "Ma, Ga, Da"),

b) protection level "mb" (EPL "Mb, Gb, Db") or

c) protection level "mc" (EPL "Gc, Dc").

The test sequence and number of samples are shown below:

2.1 Maximum temperature

A sample of "m" equipment shall be subjected to a type test to ensure that:

a) the temperature limits are not exceeded in normal operation;

b) for level of protection "ma" and "mb" the maximum surface temperature is not exceeded under fault conditions.

For "m" equipment without an external load, the test shall be carried out in accordance with the temperature measurements of IEC 60079-0 taking into account the supply conditions.

2.2 Thermal endurance test

2.2.1. Thermal endurance to heat

- for level of protection "ma" and "mb", the test shall be carried out in accordance with IEC 60079-0. The temperature to be used as the reference service temperature for the test shall be either:

a) the maximum surface temperature of the test sample under normal operation plus 20 K;

or

b) the maximum temperature at the component surface in the compound under normal operation;

- for level of protection "mc", the test shall be carried out in accordance with IEC 60079-0.

The temperature to be used as the reference service temperature for the test shall be the maximum surface temperature under normal operation.

2.2.2. Thermal endurance to cold

The test shall be carried out in accordance with IEC 60079-0.

After each test the sample shall be subjected to a visual inspection. No visible damage to the compound that could impair the type of protection shall be evident, for example cracks in the compound, exposure of encapsulated parts, failure of adhesion, inadmissible shrinkage, discoloration, swelling, decomposition or softening. A

discoloration on the surface of the compound is permissible (for example oxidation in the case of epoxy resin).

2.3 Dielectric strength test

The test shall be carried out on the following arrangements of circuits as applicable:

a) between galvanically isolated circuits;

b) between each circuit and all earthed parts;

c) between each circuit and the surface of the compound or the non-metallic enclosure that, if necessary, can be clad with a conductive foil.

For arrangement a), the voltage U to be used shall be the sum of the rated voltages of the two circuits being tested and for arrangements b) and c), the voltage U to be used shall be the rated voltage of the circuit being tested.

For arrangement b), circuits that contain transient suppression components connected between the circuit and the earthed parts, a special test sample without these components shall be permitted for the type test.

Dielectric strength shall be verified by test:

- either as given in a relevant industrial standard for the individual items of electrical equipment or,
- at the test voltage according to 1) or 2) below, and increased steadily within a period of not less than 10 s until it reaches the prescribed value, and it shall then be maintained for at least 60 s without dielectric breakdown occurring.

The test voltage shall be increased steadily within a period of not less than 10 s until it reaches the prescribed value, and it shall then be maintained for at least 60 s.

2.4 Cable pull test

The test shall be carried out on one sample, previously unstressed and at 21 °C ± 2 °C.

A further test sample shall be subjected to the cable pull test after conditioning at the maximum temperature at the cable entry point. The tensile force (in Newton) applied shall either be 20 times the value in millimeters of the diameter of the cable or 5 times the mass (in kilograms) of the “m” equipment, whichever is the lower value. This value can be reduced to 25 % of the required value in the case of permanent installations. The minimum tensile force shall be 1 N and the minimum duration shall be 1 h. The force shall be applied in the least favorable direction.

After testing, the sample shall be subjected to a visual inspection. Visible displacement of the cable, which affects the type of protection, shall not be evident. No damage to the compound or cable that could impair the type of protection shall be evident, for example, cracks in the compound, exposure of the encapsulated components or failure of adhesion.

2.5 Pressure test for Group I and Group II electrical equipment

For level of protection "ma" with any individual free spaces between 1 cm^3 and 10 cm^3 and level of protection "mb" with any individual free spaces between 10 cm^3 and 100 cm^3, two test samples shall be prepared with a pressure connection. Where there is more than one free space of a size requiring testing, the pressure test shall be carried out simultaneously in all those free spaces. The pressure test shall be carried out on samples that have already been submitted to the thermal endurance tests. The test shall be carried out with a pressure as shown in Table 1 applied for at least 10 s.

Table 1. ***Test pressure***

Minimum ambient temperature °C	Test pressure kPa
≥ –20 [(a)]	1 000
≥ –30	1 370
≥ –40	1 450
≥ –50	1 530
≥ –60	1 620
[a)] This covers equipment designed for the standard ambient temperature range specified in IEC 60079-0.	

As an alternative for 'mb' equipment if the component with a free space up to 100 cm^3, prior to encapsulation, passes the Leakage test on sealed devices specified in IEC 60079-15 (without the conditioning, voltage, or dielectric withstand testing) it can be encapsulated without requiring the pressure test. After testing, the samples shall be visually inspected. No compound damage (such as cracks in the compound, exposure of the encapsulated components or failure of adhesion) that could impair the type of protection shall be evident. For constructions that are permitted to have no thickness of compound between a free space and a non-metallic enclosure wall, there shall also be no damage to the non-metallic enclosure wall(s).

2.6 Sealing test for built-in protective devices

The test is to be performed on five samples. With the test samples at an initial temperature of (25 ± 2) °C, they are suddenly immersed in water at a temperature of (50 ± 2) °C to a depth of not less than 25 mm for at least 1 min. The devices are considered to be satisfactory if no bubbles emerge from the samples during this test.

3. CONCLUSIONS

1) This paper presents the main tests for electrical apparatus with encapsulation protection type.
2) Analysis specific requirements of the standard SR EN 60079-18 on the evaluation equipment with type of protection encapsulation "m" highlighted compound role in the determination of applicable defects in the phase of explosion protection evaluation.
3) Presentation in the requirements of water absorption test for explosion-protected equipment through the types of protection encapsulation "m", being one of the basis tests for these.
4) The increased complexity of the circuits of the equipment involved in the production process using a compound and conceiving with regard to protection from explosion due to thermal effects to which they may be subjected to.
5) Standardized values imposed by the requirements of isolation distances resulting from the simplified assessment process are superior to those which can be implemented which often leads to rejection of rated equipment.
6) The aim is to study different types of compound to satisfy the mechanical and thermal resistance, to dissipate the thermal effects caused by overheating the electric and electronic components included in the compound without them affecting the electric equipment safety of use. This aspect is primarily important due to a high number of equipment which operates in explosive atmospheres hazardous areas where the temperature varies between - 30˚ C ÷ +50˚ C.

4. ACKNOWLEDGMENTS

This article uses the experimental results obtained within the project PN 18 17 02 01 of the „Nucleu" Program developed with the help of ANCSI.

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