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Particular aspects of the tests for ignition of small components

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Abstract. The use of flammable substances in the industry means that the installations that process them generate explosion hazard zones in the proximal space. Equipment installed and operated in such hazardous areas must not ignite an explosive atmosphere. Confirmation of how equipment is adapted for use in an explosive atmosphere is named explosion protection. Explosion protection is confirmed by testing together with evaluation. For low-current equipment, the situation in which the hazardous atmosphere can be ignited by small components should be considered. The first part of the paper was devoted to the presentation of the explosion hazard and a brief presentation of the classification of equipment intended for use in explosive atmospheres. In the second part, the test methodology for ignition from small components is presented and in the last part, the results of ignition tests from small components are presented. The resulting main conclusion underlines the importance of test conditions.

1 Introduction

In recent times, the emergence of new (integrated) components and technologies has generally shortened the time from idea to design, implementation and manufacture of electrical equipment. Thus, adapting such equipment to the specific requirements of using them in potentially explosive atmospheres is considerably slowed down. This is not due to a lack of suitable components, but mainly to the lack of experience against the standardized requirements for the construction and use of electrical equipment in potentially explosive atmospheres 1-5.

In addition, the process is slowed down by the fact that standards in this field in the world, in Europe, and Romania have become more dynamic, caused in particular by the process of homogenization and globalization initiated and maintained by the IEC.

This paper aims to identify specific aspects that may influence the quality of ignition testing of small hot components.

By 6, electrical equipment 7 intended for operation in potentially explosive atmospheres, may be intended for Group I - electrical equipment for firedamp mines or

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Group II - electrical equipment for locations with potentially explosive atmospheres other than firedamp mines.

Most of the standards used in Europe in this field are initiated by the International Electrotechnical Commission (IEC) and adopted by CEN and CENELEC. Therefore, the standard 8 setting out the general requirements for electrical equipment used in places where flammable substances may occur is taken from the IEC. According to this standard, explosive atmospheres are divided into three groups, and the third group is reserved for flammable dust clouds, which have been taken over from group II.

Electrical equipment in Group II is divided into IIA, IIB, and IIC according to the potentially explosive atmosphere for which it is intended. Thus, equipment marked IIB is eligible for applications requiring Group IIA equipment. Similarly, equipment marked IIC is acceptable for applications requiring Group IIA or IIB equipment. Electrical equipment intended for use in an explosive atmosphere must be assessed, tested, certified, and appropriately marked by the manufacturer.

The risk of ignition from hot surfaces must be taken into account so that the correlation between the maximum surface temperature and the ignition temperature of the flammable substance is taken into account 9, 10.

The correlation between the equipment category and the zone index shall also be taken into account.

The method of compliance with the provisions of the ATEX Directive is based on the use of harmonized standards for the design and manufacture of equipment intended for use in potentially explosive atmospheres. Thus, by using harmonized standards of the EN 60079 series, the manufacturer will use technical solutions materialized by types of protection.

The type of protection represents specific measures consisting of specific constructive measures, which are applied to equipment to prevent the ignition of a surrounding explosive atmosphere.

Different sets of requirements have led to different types of protection for equipment. There are types of protection suitable for gas, dust, or non-electrical equipment.

2 Materials & methods

It is known that the smaller the surface is, the higher the surface temperature could be without the risk of ignition of an explosive atmosphere.

For small components, e.g., resistors or transistors, the temperature is permitted to exceed the allowable temperature corresponding to the temperature class. It can be accepted if the small component ignition test was conducted or the power dissipation is lower than 1.3 W for group II and 40°C - maximum local temperature. For higher local temperatures, lower power values up to 1 W are also accepted.

Increased temperature thresholds, depending on the size of the heated surface, are permitted according to the specific standard.

The present approach is focused on the electrical scenarios and their consequences on the thermal effect on the tested component.

The test stand consists of an aluminum enclosure with a volume of approximately 1.5 liters which is placed on a heater. In the enclosure are placed: the component under test and, at a distance of 5 mm, a thermocouple. Two more thermocouples are located outside the enclosure: one for measuring the temperature in the laboratory and the other for measuring the temperature of the heater.

Temperature and source voltage are monitored with a data logger connected to a computer system.

The supply of the component under test is made by a dual-source power supply.

The enclosure has watertight cable ducts, and two ports for connecting the oxygen analyzer for measuring the concentration of the explosive test mixture.

The diethyl-ether liquid is dripped through the upper orifice and evaporates inside the enclosure. The circuit for measuring the concentration of the explosive test mixture also homogenizes the mixture using the analyzer's internal oxygen pump.

The thermocouple is used to monitor the ambient temperature inside the enclosure, close to the component under test. This thermocouple also confirms the ignition of the explosive test mixture.

The value of dissipated power on the small component under test was 1.5 W. The tested component is a resistive one and the chosen electrical parameters are 6.165 V and 0.243 A. In the heating up process, the tested component increases its temperature and therefore, increases its electrical resistance.

The measured value of internal resistance of the tested component, at room temperature of 20°C, was 19.2 Ω.

The above-mentioned values of the electrical parameters were obtained following an iterative process in which, at thermal stability, the value of dissipated power in the component was 1.5 W.

The first scenario involved powering the component at a constant voltage of 6.165 V, during the test and keeping it supplied up to thermal equilibrium, which occurs at 1.5 W.

In the second scenario, the component was supplied at a constant current of 0.244 A and the voltage was limited to prevent the power dissipation at higher values than the prescribed value of 1.5 W.

The test procedure comprises the following steps: refreshing the test chamber with air; preheating the test chamber at a temperature near 40°C; dropping an amount of liquid diethyl-ether to evaporate; homogenizing and monitoring the diethyl-ether concentration to be 23% v/v; supplying the component monitoring the supplied power and local temperature near the component and finally, after the ignition, the test chamber is refreshed with air.

3 Results and discussions

During the test, according to the first scenario, premature ignitions of the test mixture consisting of diethyl-ether and air, occurred. An explanation for this behavior was the fact that, at the very first stage of the test, the tested component was exposed to higher power levels due to the lower values of its internal resistance.

In the very first time of the bunch of tests, the adjusting of ambient temperature was made. It is seen that the temperature before each test is near 40°C except last two where the temperature is near 45°C.

From figure 1 it can be seen that most of the temperature peaks vary between 60°C and 70°C even for those where the ambient temperature was 5 K higher.

Figure 2 shows the periods during which the tested component was powered. Also visible are the peak power values around 1.5 W.

Figure 3 shows a detail of the temperature increase in the vicinity of the tested component. In this diagram, it can be seen that the initial ambient temperature is around 40°C. This is followed by a steep period of temperature rise due to the heating of the component under test.

During the saturation period due to heating of the component under test, there is an abrupt rise in temperature due to the ignition of the explosive test mixture.

The portions of temperature decrease are due to the cooling of the burnt mixture and disconnection of the test component.

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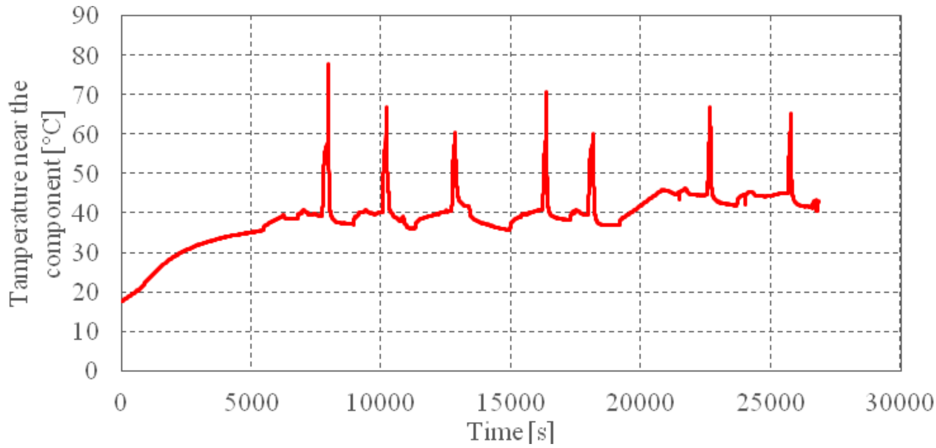

Fig. 1. Temperature variation, near the tested component.

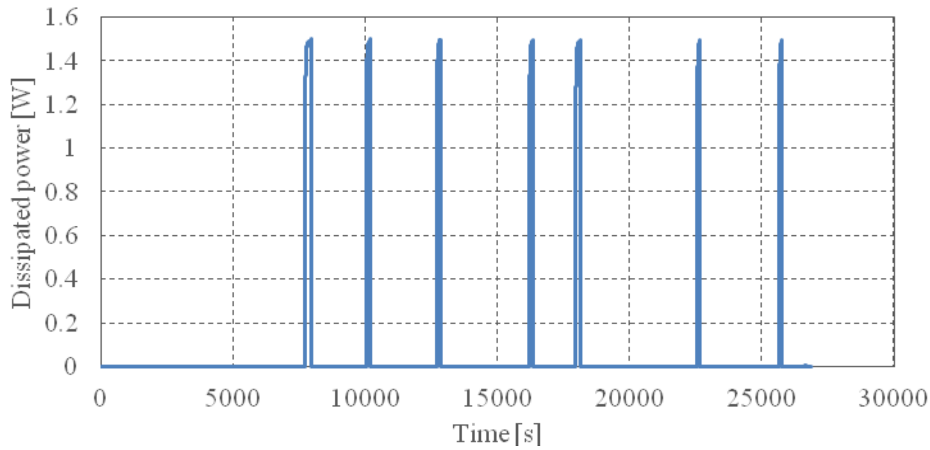

Fig. 2. Dissipated power on the tested component for all tests.

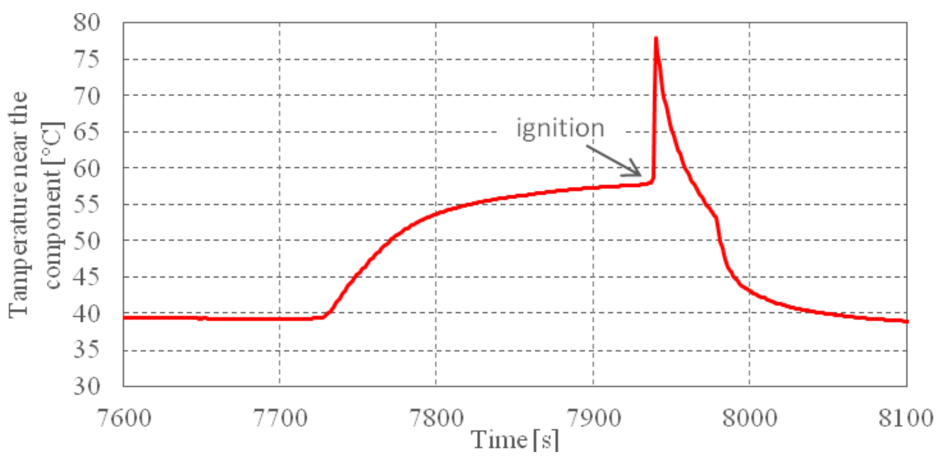

Fig. 3. Temperature variation, near the tested component.

Similar to Figure 3, Figure 4 and Figure 5 shows the variation of power dissipation on the tested component. The power also has a saturation period where the ignition of the test mixture is confirmed by increasing power, which is due to the increase in electrical resistance due to the temperature rise during the burning of the test mixture.

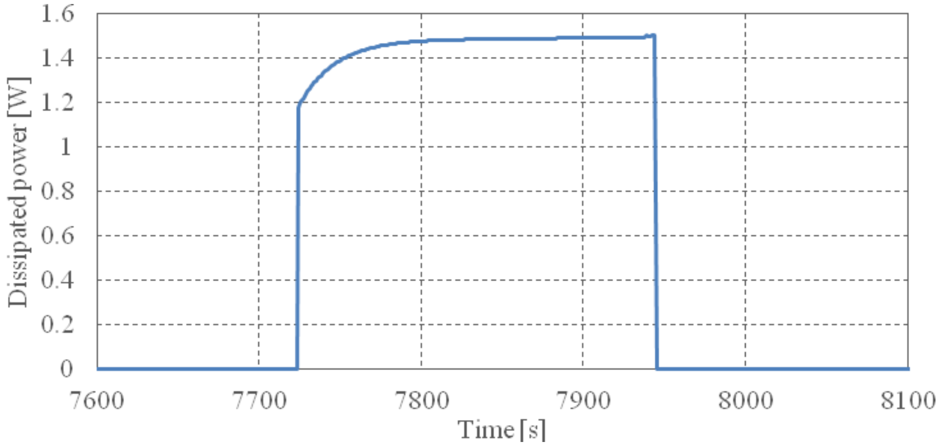

Fig. 4. Dissipated power on the tested component.

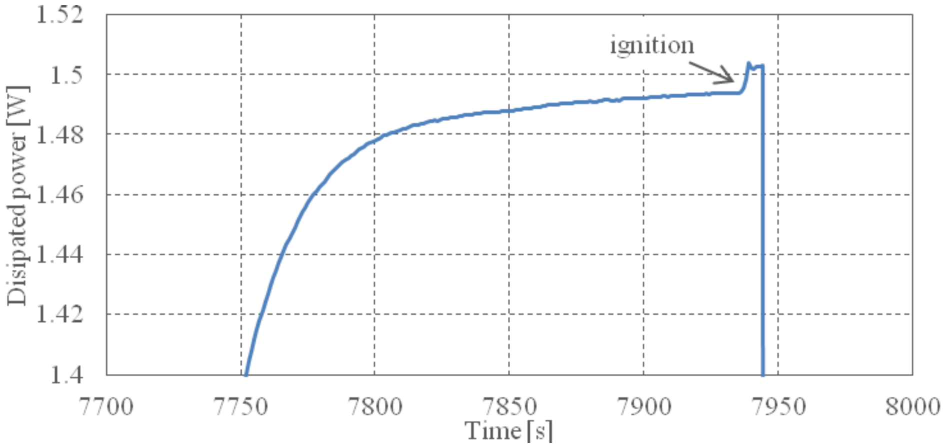

Fig. 5. Dissipated power on the tested component, the zoom of pick.

4 Conclusions

The use of a current source to power the component under test allowed the adjustment of the power dissipation on the component, at thermal equilibrium, to the set value of 1.5 W.

The temperature rise of the tested component was confirmed both by the temperature recorded by the thermocouple in the vicinity of the component and by the change of the dissipated power per component due to the increase of the electrical resistance of the component.

The ignition of the test mixture, due to heating of the tested component, was confirmed both by the temperature recorded by the thermocouple in the vicinity of the component and by the variation in power dissipation per component due to the increase in electrical resistance of the component.

The tests carried out confirm previous research, which states that small components can have a higher temperature than the temperature class allowed for non-ignition of the explosive test mixture.

For the tests, it was used apparatuses from the project "Development of laboratory analytical methods for the characterization of hazardous substances involved in fire/explosion events to increase technical expertise capacity" - PN19210103.

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