MATEC Web of Conferences **373**, 00006 (2022) https://doi.org/10.1051/matecconf/202237300006
UNIVERSITARIA SIMPRO 2022

Determination by standardized test methods of electrostatic discharge sensitivity of electric igniters in order to prevent their unexpected initiation

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Abstract. In the case of use of the electric igniters, in various applications, depending on their field of use, there may be a risk of unexpected initiation by means of electrostatic discharges from persons, their clothing and / or objects isolated from the ground. Electrification and consequently the accumulation of dangerous electrostatic potentials on people and on their outerwear, generally takes place during the performance of work tasks, a situation in which due to the movements performed by the persons involved, there is the phenomenon of friction between different parts of clothing or between clothing and the person wearing the clothing. The presence of the risk of unexpected initiation of electric igniters by electrostatic discharge requires the adoption and implementation of measures to minimize their effects on the safety and health of workers and others. In view of the above, determining the performance of sensitivity of electric igniters to unexpected initiation by electrostatic discharge is very important as this depends on the safety and security of workers / persons involved in activities that require the use of these elements / products.

1 Introduction

Electric igniters are part of the category of ignition devices, along with other generic types such as pyrotechnic chain components, wicks and pyrotechnic igniters, delayed wicks and warheads.

Generally, igniters contain a pyrotechnic composition used to initiate combustion or deflagration, and may be operated by chemical, electrical, optical or mechanical means. Electric igniters are electrically operated, the electric current being used to heat a resistive element (conductive bridge).

The sensitive pyrotechnic composition in contact with the resistive element is thus ignited by heat transfer, the article initiating a pyrotechnic chain or component by the deflagration which is generated.

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The essential safety requirements for ignition devices/igniters, including electric igniters, are found in the standard SR EN 16265:2016, GD 1102/2014 and Directive 2013/29/EU, according to which igniters for initiation are pyrotechnic articles, which can be classified in category P1 or P2 depending on the satisfaction of the requirements concerning the presence or absence of the pyrotechnic composition, respectively whether the igniter is designed so that its assembly with any other article constitutes or does not constitute a pyrotechnic operation [3,4].

One of the essential safety requirements refers to the safety characteristics of electric igniters in order to avoid their untimely initiation caused by the occurrence of an electrostatic discharge.

The electrostatic potential accumulated by the people who use, manipulate these pyrotechnic articles, respectively their outer clothing, leads to the appearance of electrostatic discharges which are sources of initiation of electric igniters.

As electrification and consequently the accumulation of dangerous potentials by the people on their outer clothing cannot be completely avoided, it is necessary to determine the sensitivity to electrostatic discharges of electric igniters in order to ensure a high degree of safety and health of persons involved in activities that require the use of these products [2].

In this context, it is very important to apply high-performance test methods that allow the determination of the safety characteristics related to the untimely initiation by electrostatic discharge of electric igniters to assess compliance with the safety requirements of the applicable regulations.

Such test methods, which allow the determination of the sensitivity to electrostatic discharges of electric igniters are given in the standard SR EN 16265:2016 “Pyrotechnic articles. Other pyrotechnic articles. Ignition devices”.

2 Test methods for determining the sensitivity to electrostatic discharges of electric igniters

2.1 Electrostatic discharge

The principle of the test method is to determine the frequency of initiation of the electric igniters tested by discharging a capacitor charged at a certain voltage, either between the electric igniter rheophores (pin to pin configuration) or between the electric igniter housing and the rheophores in short-circuit (pin to case configuration) [5].

The equipment required to perform the electrostatic discharge test consists of an electrostatic discharge generator, with capacitors with an electrical capacity between 500 pF and 3500 pF and a voltage sufficient to generate the required pulse, equipment for recording ESD current and calculating the ESD pulse applied to the electric igniter.

Performing the test method involves first adjusting the ESD generator, and this can be done using the assembly shown in Figure 1. The assembly shown schematically in Figure 1 includes the following [5]:

- ESD generator;
- cables to connect the ESD generator and the rheophores or connector of the electrical igniters to be tested;
- a resistor with a direct current resistance equivalent to that of the incandescent wires of the electric igniter;
- inductively coupled current probe with a bandwidth of at least 10 MHz;
- oscilloscope capable of integrating and calculating functions squared with a bandwidth of at least 20 MHz.

When adjusting the ESD generator, it is important that the ESD generator, rheophores and cables, resistor and all measuring equipment are placed in the same positions as those used to test the electric igniters under test.

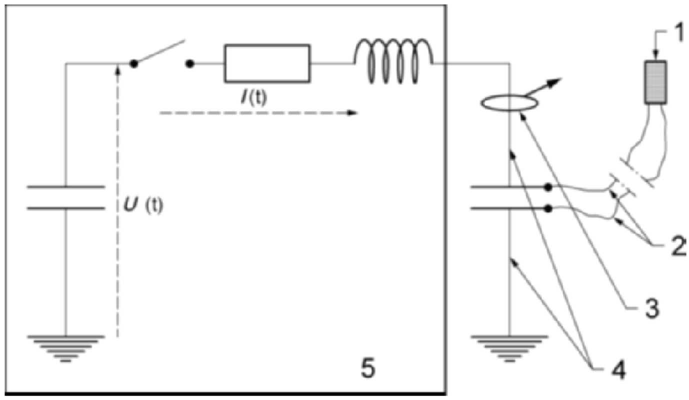

Fig. 1. Assembly for adjusting the ESD generator

1 - equivalent resistance in direct current;
2 - connecting conductors;
3 - current probe for oscilloscope;
4 - cable to the electric igniter;
5 - ESD generator.

The adjustment procedure of the ESD generator involves the assembly shown in figure 1. In order to not create earth leakage paths, a distance of at least 100 mm must be ensured between rheophores, cables and resistance, if all this exists and the ground and any conductive objects.

The current probe must be placed on one of the rheophores or on the connecting cable after which an initial applied voltage equal to twice the average breakdown voltage of the electric igniter to be tested is selected.

Apply the discharge after which the current time curve is recorded and the ESD pulse is calculated with the formula [1]:

$$W_{ESD} = \int_{t_1}^{t_2} i^2 \cdot dt \qquad (1)$$

where:

i is the current in amperes (A);

t_1 is the time after which the current appears in seconds (s);

t_2 is the time in seconds after which the current has decreased to the extent that the oscillations no longer exceed the ignition current of the electric igniter.

Finally adjust the voltage to repeat the procedure described above until the calculated pulse is equal to the required value.

If the voltage required to obtain the required pulse is less than the ignition voltage of the electric igniter, the capacity is changed to the nearest available lower value.

After adjusting the ESD generator and selecting the number of electric igniters, is verified and ensured that the rheophores, connecting cables, if any, are at least 100 mm from the ground and any conductive elements that could constitute the ground leakage paths.

The ESD pulse applied to the electric igniters shall be in accordance with Table 1, the test being performed at (20 ± 5) ºC and a relative humidity of not more than 60% [5].

Table 1. Minimum ESD pulse [5]

Non ignition current (A) [a]	$0,15 \leq I_{NF} < 0,25$	$0,25 \leq I_{NF} < 0,45$	$0,45 \leq I_{NF} < 1,20$	$1,20 \leq I_{NF} < 4,00$	$4,00 \leq I_{NF}$
Minimum ESD pulse for configuration „pin to pin” (mJ/Ω)	0,2	0,3	6	60	300
Minimum ESD pulse for configuration „pin to case” (mJ/Ω)	0,6	0,6	12	120	600
[a] value set by the manufacturer					

After the ESD pulse is applied, each applied pulse is monitored and it is monitored whether or not the electric igniter is started. The test is repeated five times in succession for each electric igniter, with a minimum of 10 s between the applied ESD pulses.

2.2 Sensitivity test

The sensitivity test applies to electric igniters with exposed pyrotechnic substances, or to other igniters when the exposed compositions are not protected by safety elements.

The circuit for performing the ESD test is as shown in Figure 2.

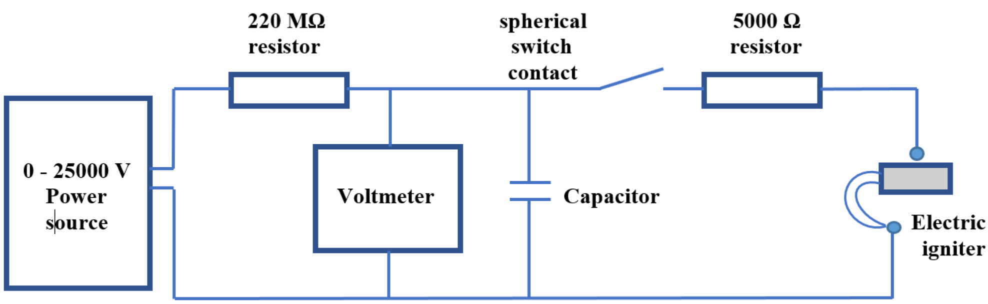

Fig. 2. Circuit for performing the sensitivity test

The sensitivity test of electric igniters involves the discharge of a voltage of 25 kV from a capacitor with a capacity of 330 pF or a voltage of 20 kV from a capacitor with a capacity of 500 pF or a voltage of 15 kV from a capacitor with capacity of 889 pF, through a 5000 Ω resistor. The sensitivity test of electric igniters shall be performed at (20 ± 5) ºC [5].

3 Laboratory testing of the sensitivity to electrostatic discharges of the electric igniters

As there is a risk of unintentional initiation of electric igniters by electrostatic discharges from persons and/or their outer clothing, laboratory tests have been performed to determine their sensitivity to electrostatic discharges in order to further assess their compliance with the essential security requirements of the applicable standards and norms.

Thus, applying one of the two standardized test methods, from the standard SR EN 16265: 2016, namely electrostatic discharge, a number of twelve electric igniters were tested, having the same design and construction of the connector and rheophores.

After adjusting the ESD electrostatic discharge generator, using the assembly in Figure 1, an ESD pulse was applied to each electric igniter, the value of which was 0.2 mJ / Ω, corresponding to the “pin to pin” configuration and the non-ignition current $0{,}15 \leq I_{NF} < 0{,}25$.

The tests were performed at 21ºC and 45% relative humidity. For each of the twelve electric igniters, the applied ESD pulse was monitored, the ESD current being recorded and then the ESD pulse was calculated using formula (1).

After the tests on the sensitivity to electrostatic discharge of the twelve electric igniters, under the conditions mentioned above and in compliance with the requirements of the test standard, no ignition was found.

The ESD pulse obtained after applying the electrostatic discharge between the two electrodes, one of them being the housing of the electric igniter, is the one in figure 3.

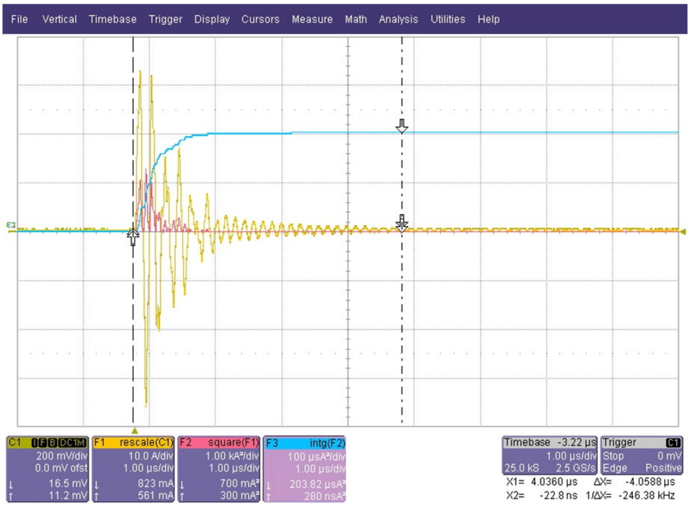

Fig. 3. ESD pulse applied to the electric igniter

4 Quality assurance of test results, requirement for conformity assessment of products

Assessing the conformity of products with the applicable essential health and safety requirements requires quality assurance of the test results, and this requires compliance, both in the pre-test stage and during the performance of all those requirements and conditions that may adversely affect the results obtained.

Several factors such as environmental conditions, test methods, measuring devices used, handling of samples, traceability of measurements and last but not least the human factor contribute to the correctness of the tests performed in a laboratory.

The factors mentioned above are not the only ones that can influence the quality of the results obtained after performing the tests, to which are added the physical and chemical properties of the tested samples.

An influence on the quality of the results obtained may also be represented by whether or not the pre-conditioning of the samples to be tested has been carried out.

In this regard, generally the standards comprising test methods specify that where conditioning is applied, the samples must be conditioned and then tested under the same conditions of temperature and relative humidity.

The devices, measuring and recording equipment used to perform the tests may influence the quality of the test results if they are not regularly subjected to a metrological verification program (calibration), an important role in use and thus the quality of the results having the human factor, which they must have the necessary competence both for the proper use of such equipment, apparatus and for the correct application and performance of the test methods [6].

At the same time, the purpose being the same, the test methods applied to determine the protection performance of the tested products must allow and ensure the reproducibility and repeatability of the results obtained given their importance for assessing compliance with the applicable essential health and safety requirements.

In the sense of the above, ensuring the quality of the results also implies the existence of necessary control procedures in the process of monitoring the validity of these results. The results obtained must be recorded in such a way that trends are detectable and, where possible, statistical analysis of the results can be applied.

Quality assurance of test results may include, but is not limited to, the requirements/conditions in Figure 4 [6].

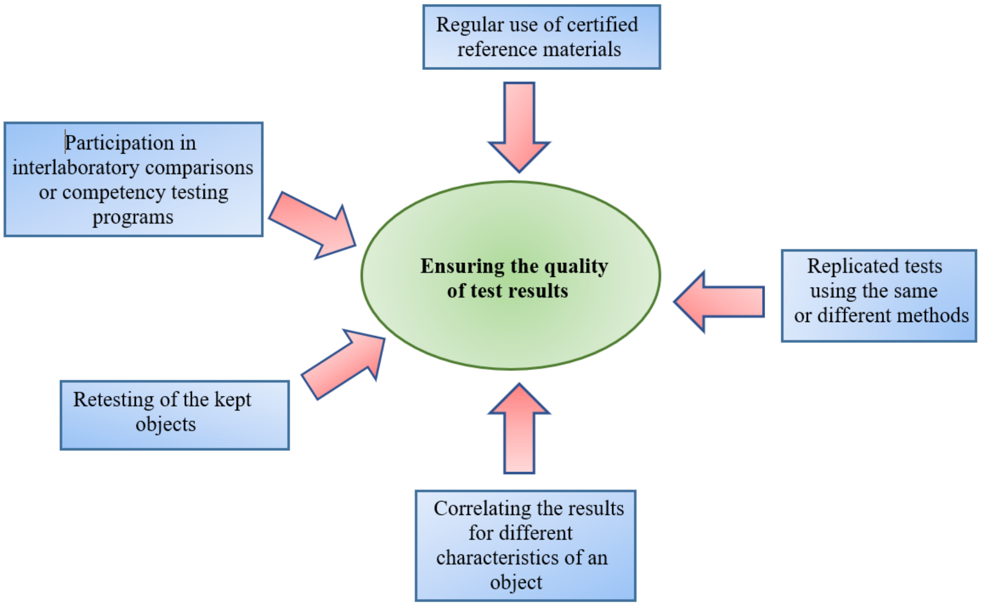

Fig. 4. Elements that contribute to ensuring the quality of test results

5 Conclusions

When using electric igniters, in various applications, depending on their field of use, there may be a risk of unintentional initiation through electrostatic discharges from people, their outer clothing and/or objects isolated from the ground.

Given the risk of unintentional initiation of electric igniters by electrostatic discharges, laboratory testing is required as a necessity, using appropriate, standardized test methods of their performance on sensitivity to electrostatic discharges.

The results of laboratory testing allow the subsequent assessment of the conformity of electric igniters with the essential safety requirements of the applicable standards and norms, thus contributing to the safety and security of workers/persons involved in activities requiring the use of these elements/products.

For assessing the conformity of products with the applicable essential health and safety requirements, the quality of the test results is of particular importance, and this requires compliance with all those requirements and conditions which may adversely affect the results of the tests carried out.

References

1. M. Părăian, Harmonized methods for testing electric detonators for assessing compliance with the requirements for the prevention of untimely detonation by electrostatic discharge - ICDE, Project **PN 07-45-02-01** (2006-2008)
2. F. Păun, M. Părăian, E. Ghicioi, N. Vătavu, A. Jurca, F. Muntean *Proceedings of the 4th International Conference on Manufacturing Science and Education MSE 2009* **7**, 534-540 (2009)
3. Government decision **1102/2014** (2014)
4. Directive **2013/29/EU** (2013)
5. Standard EN **16265** (2016)
6. Standard EN ISO/IEC **17025** (2018)