

AN INNOVATIVE METHOD FOR TESTING ELECTRONIC DETONATING CAPS REGARDING SENSITIVITY TO ELECTROSTATIC DISCHARGES

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Abstract: *The paper present the issue of explosion risk assessment presented by the risk of accidental initiation of electrical detonating caps and pyrotechnic articles. The purpose of the explosion risk assessment is to establish appropriate protection measures to prevent or limit them.*

1. Introduction

The development of new test methods and procedures, in accordance with international principles and practices, ensures the accurate assessment of the characteristics of technical equipment, equipment intended for use in environments with potentially explosive atmospheres. Thus, they align with the European practice in the field, as well as with the development of the testing laboratory within INCD INSEMEX Petroșani, in accordance with the principles and requirements of the standard SR EN ISO / CEI 17025: 2018, to provide the data necessary to assess compliance with the essential requirements. safety and health requirements of the applicable European Directives

This paper presents the development and development of test methods / procedures, by providing the necessary facilities / infrastructure, given the general upward trend of increasing the level of safety and health of workers working in potentially explosive industries.

2. Realization of the test stand for testing detonating caps regarding protective performance against uncontrolled initiation by electrostatic discharges

We made the test stand, respecting the standardized principle scheme, scheme shown in figure 1. [1]

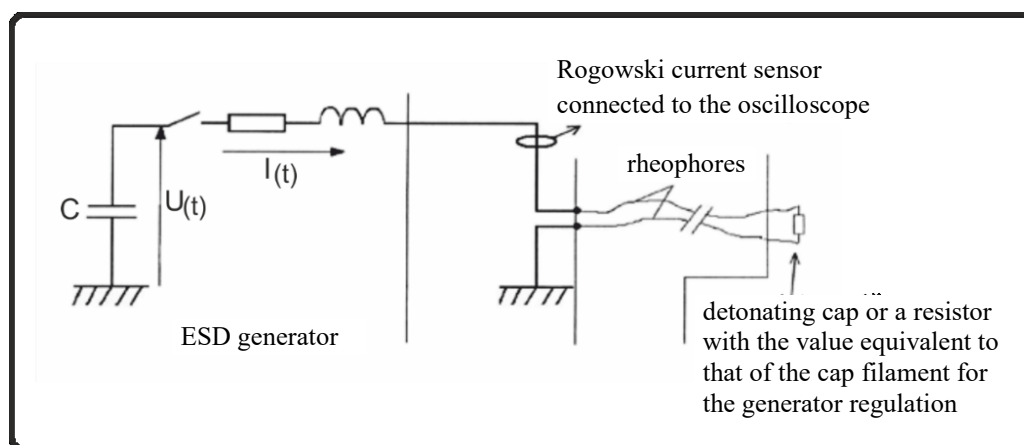


Figure 1. Installation of the test apparatus

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The test stand for testing the caps on the performance of protection against uncontrolled initiation by electrostatic discharges, made by us (figure 2), consists of:

- Electrostatic discharge generator (ESD generator) consisting of a battery of capacitors with capacities from 500 pF to 3500 pF, capacitors with operating voltage over 30 kV and a DC voltage source over 30 kV (HCP type source 260-120,000 with voltage up to 120 kV);
- System for recording ESD current and ESD pulse calculation supplied to the detonating cap, system composed of an induced coupled current sensor Rogowski type CWT015B / 1 / 80UM, an oscilloscope with mathematical functions capable of integrating and calculating quadratic functions, with a width of 500 MHz band, LeCroy WaveRunner 6000A type, DSO series;
- Calibration resistors, high voltage connection cables, vacuum electromagnetic relay controlled from a power supply, air dryer to maintain a relative humidity of up to 60%, type HBC ADSORPTIONSENTFEUCHTER CR 750, air conditioning system to maintain a temperatures of $(20 \pm 2) ^\circ\text{C}$.

The test stand was made using the equipment purchased in research projects carried out within INCD INSEMEX Petroșani.

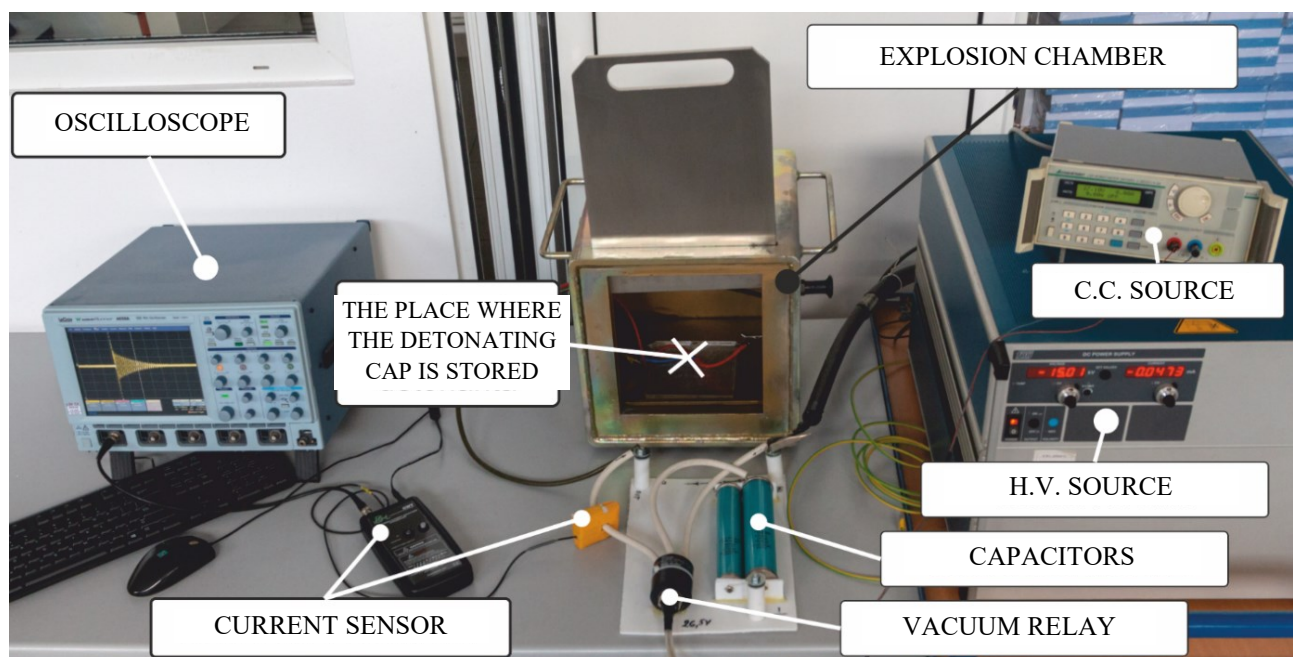


Figure 2. Cap for testing the performance of protection against uncontrolled initiation by electrostatic discharge.

3. Experimentation and implementation of the procedure in the accredited test laboratory

The experiments performed in the laboratory aimed at obtaining a working procedure through which to obtain optimal, repetitive and reliable results [2, 3].

An important step is to adjust the electrostatic discharge generator. To do this, assemble the ESD generator and the equipment. It is checked if the rheophores, cables (if any) and the resistor are kept at a distance of at least 100 mm from the ground and any other good conductive object that could cause earth leakage.

The inductive current sensor must be located on the connecting cable. The high voltage source is set to an initial value twice the average bypass voltage of the detonating cap to be tested. The discharge is applied and the current is recorded as a function of time.

NOTE: The curve must have a decreasing and oscillating shape (slightly harmonized) as in Figure 3.

The ESD pulse was calculated, W_{ESD} , from the equation:

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

where:

i - current, in amperes;

t_1 - the time at which the current begins to flow, in seconds;

t_2 - the time, in seconds, at which the current dropped to the point where the oscillations no longer exceed the non-ignition current of the detonating cap, determined according to standard EN 13763-17.

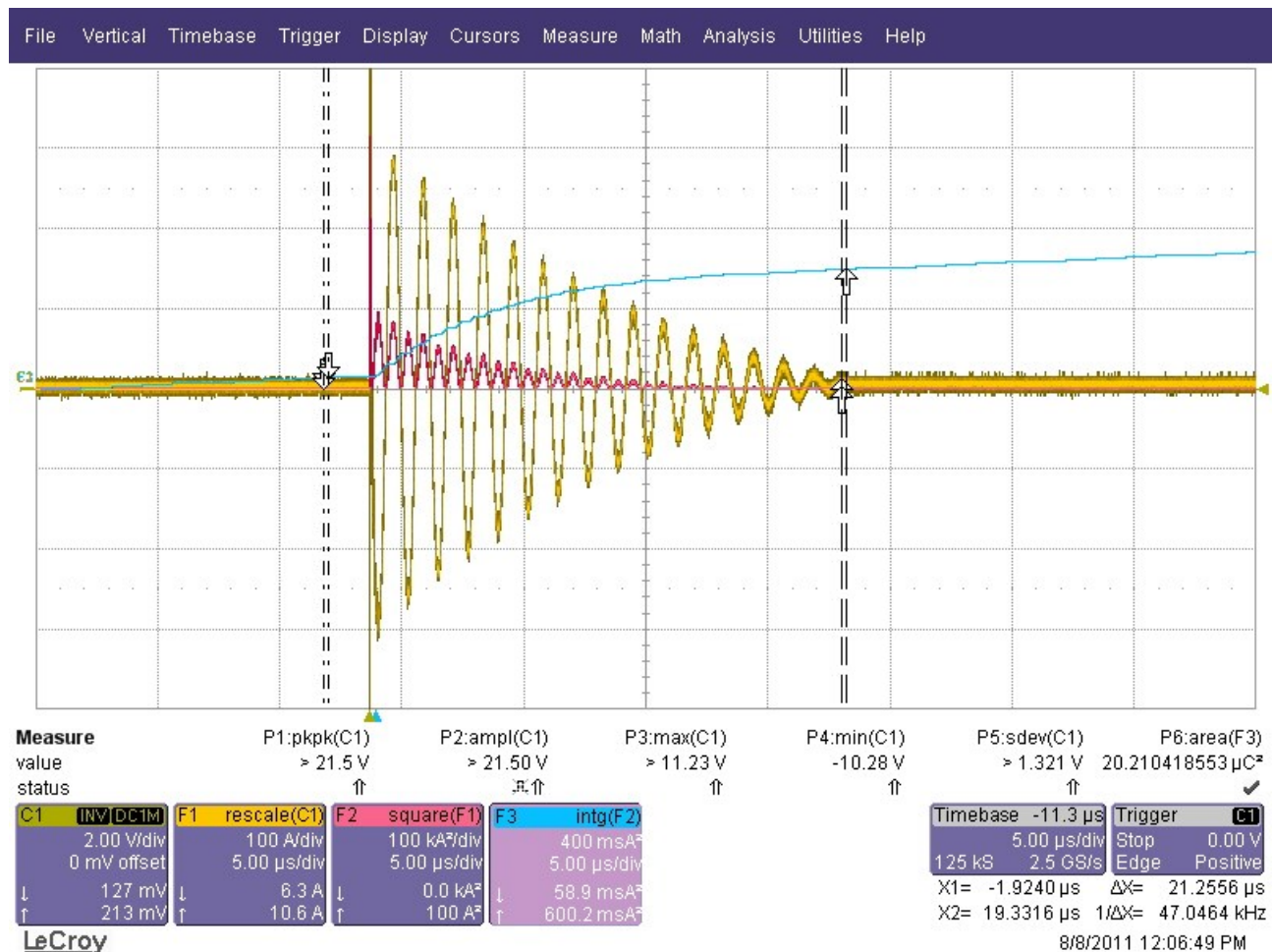


Figure 3. Pulse oscillogram and curves generated by mathematical functions

The following steps are used to monitor the pulse:

- The discharge pulse is recorded on the oscilloscope (current variation as a function of time), function F1;
- Set the oscilloscope to generate the F2 function by multiplying the F1 function by the sensitivity factor of the CWT1 current sensor (20 mV / A);
- Set the oscilloscope to generate the F3 function by squaring the F2 function;
- Set the oscilloscope to integrate the F3 function on the interval t1 (the time at which the current begins to flow) and t2 (the time at which the current has decreased to the point where the oscillations no longer exceed the ignition current of the detonating cap);
- Adjust the voltage and repeat the operation described above until the calculated pulse is equal to the required value. If the voltage required to reach the required pulse is less than the bypass voltage of the detonating cap, the capacity is changed to the nearest available lower value.

According to clause 4.18 of SR EN 13763-1, the lower value of the bypass voltage must be greater than 1500 V and the upper value of the bypass voltage must be less than 6000 V [4].

The capacity of the capacitor is determined so that the pulse supplied to the cap has the values in the standard, presented in table 1.

Table 1 ESD pulse values depending on the class of the detonating cap and the configuration

Detonating cap class	Pulse ESD (mJ/Ω),	
	ESD pulse (mJ / Ω), for "electrode to electrode" configuration	ESD pulse (mJ / Ω) for the "housing electrodes" configuration
Class 1	0.3	0.6
Class 2	6	12
Class 3	60	120
Class 4	300	600

From the values given in the table it is observed that the electrostatic discharge generator must provide a current pulse in the range 0.3 - 600 mJ / Ω .

To avoid defects and erroneous results, the limitations of the test apparatus must be observed, as follows:

- The maximum current for the inductively coupled current probe must not exceed 300;
- The voltage of 30 kV must not be exceeded, as this is the maximum voltage supported by the capacitors.

4. Conclusions during laboratory tests carried out on electronic detonating caps during the stand experimental phase

From the experiments performed, the following conclusions were found:

- The test results, respectively the shape of the discharge pulse, are strongly influenced by the configuration of the discharge circuit. In order to obtain a decreasing and oscillating (slightly harmonized) discharge curve, as specified in the standard, it is necessary to reduce the inductance of the electrical circuit as much as possible;

- Grounding, faulty grounding of the test circuit leads to erroneous results. The discharge curve is strongly distorted due to stray currents;

- The ambient temperature influences the measuring equipment;

- The test performance of the stand is limited by the inductive coupled current sensor CWT1 which supports a peak current of 300 A and the vacuum relay which, at very high currents, can remain with the fittings glued, failing.

From the analysis of the standardized test requirements, the technical characteristics of the test apparatus and the results obtained, it can be seen that the existing test apparatus offers the possibility to determine the sensitivity of electrical detonating caps to electrostatic discharges. This determination is made in accordance with the standardized test requirements contained in the standard SR EN 13763-13: 2004 [4, 5]

The following requirements shall be considered when performing the tests:

- the storage, transport and handling of caps will be done in compliance with the actual legislation on explosive materials;

- the test site must provide the specific conditions for the test, that means an adequate earthing network, an air-conditioning system to maintain a temperature of $(20 \pm 2) ^\circ\text{C}$ and a relative humidity of not more than 60%, both for the conditioning of the samples according to the standard, but also for the good functioning of the electronic measuring and monitoring equipment.

5. Conclusions

Explosives for domestic use, which also include electric detonating caps, in certain situations, can be initiated untimely due to electrostatic discharges. Static electricity, as a source of electrostatic discharge, is a common phenomenon in the explosives industry.

Determining the performance of the sensitivity of these devices to untimely initiation by electrostatic discharge is very important, as it depends on the safety and security of the persons. From the study performed on the test methods of the safety parameters of the electric detonating caps, of the pyrotechnic articles, of the propellants and of the fuels for missiles regarding the initiation by electrostatic discharges we found that they were not implemented in the INSEMEX laboratories. In this sense, we performed a series of studies that ended with the construction of the test stand for testing detonating caps on the performance of protection against uncontrolled initiation by electrostatic discharges.

By putting into practice the obtained results, we have made an important contribution to the development of methods and means of protection against static electricity, in order to ensure a high level of work safety in areas with potentially explosive atmospheres and shooting work.

Theoretical but also practical studies, analysis of technical and safety requirements, experimentation of test methods, laboratory research and methods of testing and evaluation of the ignition hazard of technical equipment, have led to improved performance of the current system of testing and carrying out the necessary assessments to certify the conformity of equipment and materials with the requirements of the European Directives.

The development of test methods by developing test and evaluation methodologies, design and design of test stands, their experimentation and validation of test methods, contributes to the development of the effectiveness of the current test / certification system of the Laboratory of Non-Electrical Equipment Ex, Electrostatics, Materials and PPE within INCD INSEMEX.

References

- [1] **Gabor D., Radu S.M., Ghicioi E., Părăian M, Jurca A., Vătavu N, Păun F., Popa M.,** 2018
Study of methods for assessment of the ignition risk of dust/air explosive atmospheres by electrostatic discharge, 8th International Multidisciplinary Scientific Symposium „UNIVERSITARIA SIMPRO” 11-13 October 2018, Petroșani, România, Conference Proceedings, ISSN–L 1842 – 4449, ISSN 2344 – 4754, Pag. 157÷162;
- [2] * * *
PN 07-45-02-01 Harmonized methods for testing electric detonators for assessing compliance with the requirements for the prevention of untimely detonation by electrostatic discharge (ICDE);
- [3] * * *
PN 07-45-02-55 - Research on the sensitivity of explosive mixtures, electric detonators and pyrotechnic articles for vehicles to electrostatic discharges. Determination of the minimum ignition energy of explosive mixtures or the initiation of pyrotechnic devices.
- [4] * * *
SR EN 13763-13:2004 - Explosives for civil use. Detonating staples and delayed relays. Part 13: Determination of the resistance of electric detonating staples to electrostatic discharge;
- [5] **Găman G.A., Gabor D., et.al,** 2018
National guide on establishing occupational safety and health requirements for economic operators operating with substances / products / goods capable of generating explosive / toxic atmospheres, or having detonating / explosive characteristics (in romanian), INSEMEX Publishing, Petroșani, România, 2018, ISBN 978-606-8761-26-8



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