



**MINISTRY OF EDUCATION**  
**UNIVERSITY OF PETROȘANI**  
**DOCTORAL SCHOOL**  
**DOMAIN: INDUSTRIAL ENGINEERING**

# **THESIS SUMMARY**

**Scientific leader:**

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**Phd. Student:**

**Eng. Cristian Raul CIOARA**

**Petroșani**  
**2024**



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# **THESIS SUMMARY**

***ÎMBUNĂȚIREA SISTEMULUI DE MANAGEMENT AL CALITĂȚII  
ÎN DOMENIUL ÎNCERCĂRII ȘI CERTIFICĂRII ARTICOLELOR  
PIROTEHNICE DE DIVERTISMENT***

***IMPROVING THE QUALITY MANAGEMENT SYSTEM IN THE FIELD  
OF TESTING AND CERTIFICATION OF FIREWORKS  
PYROTECHNIC ARTICLES***

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## **Keywords**

For a good understanding of the following doctoral thesis, it is necessary to list some notions specific to the field addressed: *entertainment pyrotechnics, quality management system, testing laboratory, certification body, testing activities, certification process, technical and methodological infrastructure, "CCMSSM-appp" application, pyrotechnician job.*

## **The motivation of the doctoral thesis**

It is based on the fact that it is essential to improve the quality management system regarding the trial/testing activity and the evaluation process for the certification of pyrotechnic articles of entertainment. In the research activity that I carried out within the Security Department of Explosives and Pyrotechnic Articles, I was directly involved as a responsible or operator, participating in various tests on pyrotechnic articles from all existing categories, and in the certification process being designated case manager or technical working group member of many certification files. From 2014 until now, I have been working in the Department of Quality, Metrology, Health and Safety at Work, as a quality assurance manager. Following the audits carried out as an observer, auditor in training, member of the audit team or head of the audit team, we found a series of non-conformities originating from the technical or methodological infrastructure or from the personnel involved in the testing activity and/or the certification process. This project was created to carry out the testing and certification activity, which involves a number of management requirements and techniques specific to the operation of the laboratory. This was done to guarantee the performance and maintenance of quality tests and certifications and to satisfy and maintain customer confidence in its competence and capability.

## **Objectives**

The main objective of this doctoral thesis is to improve the quality management system in the field of testing and certification of entertainment pyrotechnic articles due to the updating, modification or change of the normative documents, the references applicable in the field and the requirements imposed by the national accreditation body RENAR. Development and implementation of new technologies and state-of-the-art equipment to provide improved control over the handling and use of pyrotechnic articles. The testing laboratory and certification body must have sufficient, properly trained staff who respect impartiality and confidentiality. Teza își propune să contribuie semnificativ la îmbunătățirea sistemului de management al calității în domeniul încercării și certificării articolelor pirotehnice de divertisment prin abordarea acestor obiective.

The doctoral thesis provides an in-depth analysis of the implementation of the quality system for the INSEMEX-GLI testing laboratory, respectively the quality system of the INSEMEX-OEC certification body. The quality systems comply with the requirements of the reference standards applicable in the field, and in this sense they are accredited by RENAR for carrying out testing activities, respectively for carrying out conformity assessment and product certification activities.

The doctoral thesis describes the existing technical and methodological infrastructure used in the testing activities and the certification process of pyrotechnic products intended for entertainment.

It presents: the tests carried out on pyrotechnic articles from categories F1, F2, F3, F4 and the way of reporting the results obtained. We have presented the theoretical and practical training module for the qualification course in the trade of pyrotechnician, which aims to complete an analytical program and focuses on the development of skills and abilities in the execution of various operations with pyrotechnic articles. The computerized system that we designed and created for the theoretical preparation and the computer-assisted intermediate and final examination is presented.

The "CCMSSM-app" application is also presented, which represents a database and a useful information system in the activities of colleagues with attributions in the field of testing, respectively certification for pyrotechnic articles and not only. A database easily accessible by all users, where information and documents are constantly checked and updated.

The doctoral thesis entitled: *Improving the quality management system in the field of testing and certification of entertainment pyrotechnic articles*, is structured in 8 chapters.

In **the first chapter**, called Introduction, the general considerations, the main objective and the specific ones, the motivation of the thesis and a brief synthesis of the work are presented.

**Chapter 2** - "*Analysis of the legislative and technical regulatory framework in the field of entertainment pyrotechnic articles*", presents a synthesis of the minimum OSH requirements applicable at national level, according to European regulations, in the field of entertainment articles, provided for by Annex 1 of Directive 2013/ 29/EU (transposed by GD no. 1102 of December 10, 2014 on establishing the conditions for making pyrotechnic articles available on the market). The constructive and performance requirements stipulated by the harmonized standards applicable in the field for pyrotechnic articles of entertainment categories F1, F2, F3 and F4 are presented. The general certificates for the competence of the testing laboratories according to the SR EN ISO/IEC 17025:2018 standard, respectively the certification bodies according to the SR EN ISO/CEI 17065:2013 standard, taking into account the observance of the quality principles, are detailed.

**Chapter 3** - "*Contributions regarding the development of the technical and methodological infrastructure for testing entertainment pyrotechnic articles*". This chapter focuses on the development and procedure of methodological tools, intended for tests to verify the functioning and determine the content of pyrotechnic articles. It describes the existing technical and methodological infrastructure for testing and testing pyrotechnic articles. The sample tests performed on pyrotechnic articles from categories F1, F2, F3, F4 and the way of reporting the obtained results are presented. The quality system in the field of testing pyrotechnic articles is highlighted, based on the requirements set out in SR EN ISO/IEC 17025:2018, to guarantee professionalism, impartiality and confidentiality.

**Chapter 4** - *"Contributions regarding the improvement of the methodological infrastructure for the certification of pyrotechnic articles of entertainment"* presents the process of development and implementation of the methodological infrastructure for assessing the conformity of pyrotechnic articles. The quality system applied in the certification process is presented, highlighting the use of the principles of impartiality, confidentiality, competence and integrity, which respect rigorous principles and practices according to SR EN ISO/CEI 17065:2013. The chapter describes the methodological infrastructure for the conformity assessment and certification activities of pyrotechnic articles, the author's experience in the research activity, as well as his role in coordinating the testing and certification process, highlighting the outstanding contributions in this specialized field. The results of the certification process are presented, completed with the issuance of a "Certificate of Conformity", for the module requested by the manufacturer, which is consistent with the rules and specifications contained in the specific system procedures.

**Chapter 5** - *"Contributions regarding the development of an improved quality management system in the field of testing and certification of entertainment pyrotechnic articles"*, presents the structure of the quality management system applied in INCD INSEMEX Petroșani, both for the INSEMEX-GLI and INSEMEX-OEC structures regarding the quality manual, system procedures, specific procedures and organization and operation regulations. Due to the updating, modification or change of the normative documents, the references applicable in the field and the requirements imposed by the national accreditation body RENAR, the quality system must be updated and permanently improved, and in this sense we developed and approved a new edition of all quality system documents. Also in this chapter the "CCMSSM-app" application, designed, made and implemented by the author, is presented. The application represents a database and a useful information system in the activities of colleagues with attributions in the field of testing, respectively certification for pyrotechnic articles and not only. A database easily accessible by all users, where information and documents are constantly checked and updated.

**Chapter 6** - *"Contributions regarding the improvement of the infrastructure intended for the theoretical and practical training of participants in the pyrotechnician qualification course"*. In the content of this chapter, I presented the way of organizing the qualification course in the profession of pyrotechnician carried out within INCD-INSMEX Petroșani. We presented the theoretical training module, which aims to go through an analytical program through which the student assimilates a series of new knowledge that he will apply, both alone and in a team. The practical training module focuses on developing skills and abilities in performing various operations correctly without generating risks for yourself or others. Also, the computerized system that we designed and created for the theoretical preparation and the computer-assisted intermediate and final examination is presented. The system is a database of up-to-date course support and current legislation that can be easily accessed by all users.

**Chapter 7** - *"Contributions regarding the development of a procedural tool regarding the technical expertise of events generated by the use of entertainment"*



*pyrotechnic articles*", describes the technical expertise procedures and techniques used to solve problems resulting from the improper use of pyrotechnic articles. The steps that must be taken to carry out a technical expertise are detailed, such as: the process of receiving and verifying the documentation, setting up the expert team, preliminary assessment, performing the tests, analyzing the results and issuing the expert report. It assesses the importance of a quality system in assessing conformity, as well as the risks associated with non-compliant use of pyrotechnic articles. Finally, considering the chapter's significant contribution to the literature and its replicable model for managing similar incidents, suggestions are made for improving safety and preventing future incidents.

**Chapter 8** – “*Final conclusions and Personal Contributions*” highlights the theoretical, experimental and applied contributions, providing a detailed analysis of the advanced research in the field of entertainment pyrotechnics.

## **Theoretical contributions**

### **From the point of view of dissemination of results:**

During the course of the doctoral activities and the initial documentation efforts undertaken, I supported/published at various symposia/conferences and/or in specialized journals, as an author or co-author, a number of 27 scientific articles and research papers divided into the following categories:

- 3 articles published in Clarivate Analytics Web of Science indexed journals - WoS (ISI);
- 24 articles published in specialized magazines;
- An **Invention Patent no. 127875** dated 28.06.2019 regarding "*Automatic installation for performing thermal cycles for the conditioning of chemical fertilizers with a high nitrogen content*", inventors: PhD. eng. Daniela Carmen Rus, PhD. eng. Attila Kovacs, Phd. Student Eng. Edward Gheorghiosu, **Ph.D. Student Eng. Cristian Cioara**, Eng. Ilici Ștefan

**The main theoretical contributions** with significant technical-scientific impact, derived from the doctoral thesis, are:

- I have carried out an analysis of the minimum occupational health and safety requirements applicable at national level, harmonized with European regulations, in the field of entertainment pyrotechnic articles, provided by Annex 1 of Directive 2013/29/EU (transposed by GD no. 1102 of December 10, 2014 regarding the establishment of the conditions for making pyrotechnic articles available on the market);

- I have carried out a documentation study from the specialized literature regarding the legislative aspects related to the regime of pyrotechnic articles, the specific terminology in the field of pyrotechnic articles, as well as highlighting the applicable requirements in order to comply with safety measures and prevent unwanted situations

when working with pyrotechnic articles , of the procedural technical aspects regarding their transport, storage or destruction;

- I have participated, as a member, in the meetings of the technical committee CT-358 "Explosives for civil use", within the Romanian Standardization Association ASRO, in the specific actions for the adoption/implementation (translation) of the standards adopted in the field of explosives and pyrotechnic articles. During 2023, specific actions were organized for the acquisition and translation of the family of standards SR EN 15947: 2022 Pyrotechnic articles. Entertainment fireworks, categories F1, F2 and F3;

- I have carried out training activities, as a lecturer for the practical training of students, at the "Qualification course for authorization in the profession of pyrotechnician", course organized within the Department of Security of Explosives and Pyrotechnic Articles;

- I was responsible for the NUCLEU Project PN 16 43 02 20 "*Research on the modernization of technical and IT facilities for the organization of qualification courses in the profession of pyrotechnician*", in which I updated the course support in full accordance with the technical and organizational requirements set out in the Occupational Standard , harmonizing from the point of view of theoretical and practical training with the required performance level, and in order to improve the conditions for the acquisition of the theoretical and practical skills of the students, specific to the profession of pyrotechnician, equipment, consumables and professional pyrotechnic articles were purchased;

- In order to elaborate this scientific paper, I consulted more than 270 bibliographic sources from specialized literature (books, articles or works in the field);

## **Experimental and applied contributions**

The main experimental and applied contributions with significant technical-scientific impact, derived from the doctoral thesis, are:

- In order to develop the technical and methodological infrastructure for verifying the operation and determining the content of pyrotechnic articles, at the level of the Explosives and Pyrotechnic Articles Security Department, state-of-the-art specialized equipment and apparatus were purchased, in which we actively participated. These facilities correspond to the requirements at the international level and correspond to the provisions of the applicable standards in the field.

- I carried out a series of experimental tests on entertainment pyrotechnic articles of categories F1, F2, F3 and F4, applying the updated test procedures whose work methodologies are developed in accordance with the requirements of the applicable referentials, "*PI-97 determination of the content of pyrotechnic articles* " and "*PI-98 Pyrotechnics Functionality Check*", using the test apparatus and equipment within the laboratory.

- In the scientific research activity that I carried out within the Department of Security of Explosives and Pyrotechnic Articles, in order to develop the technical infrastructure for checking the functioning of pyrotechnic articles, together with the research team from this department, I designed, made and patented the "*Apparatus of mechanical shock for the mechanical conditioning of pyrotechnic articles*", invention patent no. 128161 of 29.11.2013.

- In the research activity that I carried out within the Security Department of Explosives and Pyrotechnic Articles, respectively the SECEMTI certification service, I was directly involved in the certification activity, being appointed case manager or member of the technical working group of many certification files.

- The quality system, from the initial accreditation to the current situation, has been improved due to the updating, modification or change of the normative documents, the references applicable in the field and the requirements imposed by the national accreditation body RENAR, in this sense I participated and actively and permanently contributed. This activity consists in modifying/adapting the provisions of the applied quality system documents.

- To improve conformity assessment activities and product certification, INSEMEX-OEC, through the SECEMTI certification service, participates in the working meetings of notified bodies at European level, where decisions are adopted and recommendations are made for the correct understanding and application of the provisions of the Directive 2013/29/EU, and not only, which must be implemented by each member (notified national body) for their uniform application. In this sense, I actively participated in the meetings organized by the forum of notified bodies, from the country and abroad. (Bucharest, Sibiu and Bratislava).

- From 2014 until now, I have been working within the Quality Department Metrology Health and Safety at Work CCMSSM, being responsible for quality assurance. As a result of the activities undertaken, as the quality assurance manager, I participated in the development and/or verification of the quality system documents regarding the Quality Manual (MC), System Procedures (PS), Specific Procedures (Psp) and Organizational/Operating Regulations . I also evaluated the activity of the test/certification process, following the audits carried out as an observer, auditor in training, member of the audit team or head of the audit team.

- Due to the updating, modification or change of the normative documents, the references applicable in the field and the requirements imposed by the national accreditation body RENAR, the quality system must be updated and permanently improved. In this sense, we performed/participated in the internal audits carried out to identify and remedy the non-conformities in the testing/certification activities.

- During the doctoral internship, following the thorough research and findings on the quality systems for INSEMEX-GLI and INSEMEX-OEC, I revised, updated and developed a new edition of the quality system documents, thus I revised the working instructions of the devices , we updated the quality and impartiality policies, developed a

new edition of the quality manual, system procedures, specific procedures and organizational and operating regulations.

- I designed, created and implemented the application "CCMSSM-app" which represents a database and a useful information system in the activities of colleagues with attributions in the field of testing, respectively certification for pyrotechnic articles and more. A database easy to access and use by all users, where information and documents are constantly checked and updated.

- I designed and created a computerized system of theoretical preparation and computer-assisted intermediate and final examination, for the "*Qualification course for authorization in the profession of pyrotechnician*". It is a database of up-to-date course material and current legislation that can be easily accessed by all users, where information and documents are constantly checked and updated. With the help of this system, course participants are examined.

- I developed the technical and IT facilities for the organization of qualification courses in the profession of pyrotechnician, by updating the course support and by purchasing some equipment and consumables used in the practical training of the students.

- As the designated person responsible for the coordination of the metrology activity, I maintained the verification, calibration and calibration of the measurement and test equipment to the terms and conditions imposed by the legislative framework. I draw up and annually improve the list of material resources used by the testing laboratory, the metrological calibration plan of the equipment used in the tests and actively participate in the intermediate checks of the equipment used in the tests. I constantly collaborate with the staff of specialized laboratories to maintain these infrastructure elements in the best working condition with the coverage of the legal framework.

- By analyzing the quality systems for INSEMEX-GLI and INSEMEX-OEC applied, an adequate level of confidence is ensured for the validity of the results of the tests carried out or the certification decisions approved, considering the procedures applied within the quality system, with an infrastructure and appropriate methodology and suitably qualified staff for implementation.

- The test procedures and the procedures specific to the described certification modules are completely adapted to the requirements of the applicable reference standards and are checked, both as content and as implementation, through internal control, internal and external audits, as well as by participating in the schemes of intercomparison of the results with similar laboratories in Europe.

- I collaborated with the certification service, INSEMEX SECEMTI, in order to participate in the schemes for carrying out interlaboratory tests (generically called Round Robin Test - RRT) organized at the level of notified bodies, which have as their object the assessment of the conformity of pyrotechnic articles and which will be tested in accordance with the methods described in the standards applicable in the field for the type and category to which the respective pyrotechnic article belongs. The main purpose of

these actions is to demonstrate the competence and maintain the credibility of notified certification bodies at European level.

- In the research activity, as well as during the doctoral internship, I was responsible for national projects (NUCLEU) or a member of their working group, and as a result of the research undertaken, the technical and methodological test/certification infrastructure was improved and modernized, through the implementation of new procedures, testing methods and/or the purchase of equipment and machinery.

### **Future research directions**

Taking into account the contributions expressed in the work and the research problem identified, the following research directions can be highlighted with the possibility of future approach:

- Extending the scope of accredited testing and certification for pyrotechnic articles that are not included in Directive 2013/29/EU, such as naval or aeronautical ones.

- The development of the technical and methodological test infrastructure to create the possibility of classifying or verifying the classification from the point of view of ADR (Agreement on the international road transport of dangerous goods) of products in the class of explosive substances.

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