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**CONTRIBUTIONS REGARDING THE  
MONITORING OF DANGEROUS WORK  
PLACES IN ORDER TO ENCREASE THE  
DEGREE OF WORK SAFETY**

***DOCTORATE THESIS***

***-Résumé-***

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# CONTENTS

<b>1. Orientations.....</b>	<b>1</b>
<b>2. Priorities.....</b>	<b>2</b>
<b>3. Problem proposed for resolution.....</b>	<b>3</b>
<b>4. Thesis objectives.....</b>	<b>3</b>
<b>5. Relevance.....</b>	<b>3</b>
<b>6. Methodological and theoretical-scientific support.....</b>	<b>3</b>
<b>7. Scientific novelty of the obtained results.....</b>	<b>4</b>
<b>8. Applicative value of the work.....</b>	<b>4</b>
<b>9. Disseminating the results.....</b>	<b>4</b>
<b>10. Publications.....</b>	<b>4</b>
<b>11. Thesis's volume and structure .....</b>	<b>4</b>
<b>12. Personal contributions.....</b>	<b>6</b>
<i>12.1. Methodological contributions.....</i>	<i>6</i>
<i>12.2. Theoretical contributions.....</i>	<i>7</i>
<i>12.3. Hardware contributions.....</i>	<i>7</i>
<i>12.4. Hardware and software contributions.....</i>	<i>8</i>
<i>12.5. Software contributions.....</i>	<i>9</i>
<i>12.6. Experimental and applicative contributions.....</i>	<i>9</i>

## **1. Orientations**

The first preoccupations for the improvement of the work conditions date back to the moment when man first began working, in other words, to consciously perform an activity of transforming the environmental elements in order to insure his existence.

In the pre-industrial centuries, research and measurements for improving the work conditions, diminishing the efforts and increasing the effectiveness had a sporadic and local character.

An increasing number of sciences began to be concerned with the relationship between man-machine-environment, such as medicine, anthropology, sociology, psychology, the economical sciences. They each analyzed the impact between man and the elements of the work process from its own view point, searching for solutions in order to protect the worker and, at the same time, increase his productivity.

From the ensemble of the practices and the researcher regarding the relationship between man and work, it was outlined, it time, as a distinct objective, the protection of the worker against the work accident and professional diseases. In most cases, however, the accidents and the professional diseases were considered to be a fatality. Later on, multiple factors, which depended on the industrial revolution and the general progress of knowledge imposed, as a matter of the outmost importance, the necessity of eliminating, or at least of reducing the number of accidents, a fact which was reflected in the creation of specific juridical regulations.

The current industrial era is accompanied, among other direct consequences, by two very important phenomena. Firstly, the risk potential for accidents and diseases during the work became increased. Automation (with the monotony and the imposed work rhythm), the new technologies (which use very high energies and require the outmost precision of execution), the raw materials used, and so on, can affect more significantly the anatomic and functional integrity of the executor. The second phenomenon consists in the increase of human value, becoming more and more aware of his role a the main resource for society's existence and progress.

Among the newly appeared areas of activity is work safety, understood as the ensemble of actions and measures taken in order to ensure the anatomic and functional integrity, as well as man's health during the work process.

The Frame Directive 89/391/CEE is the most important regulation concerning the work safety and health for the European Union. It has as generator element the treaty of

application of CEE, in which, in art. 118a the minimum requirements in the field are stipulated, in order to guarantee a high level of worker protection.

In order to reach the objective of stimulating the measures for the improvement of the work safety and health conditions, the Directive contains general principles, as well as general guidelines for their implementation, which refer to: the prevention of professional risks which have not been eliminated by design; protection of the work safety and health; eliminating the risk factors for accidents; information, consultation and training of the workers.

## **2. Priorities**

The E.U. policies regarding the work safety and health, transposed in the Romanian legislation (Law No.319/2006 – law of the work safety and health) mainly refer to:

- instituting measures regarding the promotion of the improved work safety and health for the workers
- determining the general principles regarding the prevention of professional risks, the protection of workers' safety and healthy, eliminating the accident risk factors, informing, consulting and training the workers.
- employers' obligation to censure the safety and healthy of the workers in all the work-related aspects.

In the work place there can be many dangers and/or risks, caused by different factors of influence, which could affect the physical and psychological health of the workers.

The factors which can influence the physical health of the worker derive from:

- *The work environment* (noise, vibrations, microclimate, lighting, etc.)
- *Means of production* (machine parts in movement, dangerous chemical agents, etc.)
- *Work task* (physical effort, incorrect or forced work positions, work monotony, etc.)
- *Unfit actions of the worker* (not complying with the work instructions, not using the individual protection equipment, moving to dangerous areas, etc.)

The employer must implement the measures for ensuring the work safety and health based on the general prevention principles. In the unit's prevention plan, those measures which refer to the protection of the workers in areas with high degrees of specific risk have priority (dangerous places), against the appearance of a severe and

imminent danger of accidents. Such dangerous work places can be found in almost all activities.

### **3. Problem proposed for resolution**

The thesis' purpose is to realize a monitoring system of the dangerous work places and a specialized software which allows the permanent and objective evaluation of the degree of safety in a dangerous work place.

### **4. Thesis objectives**

They consist in:

- Identifying, adapting or elaborating a method of evaluating the professional risk factors which can be implemented with the help of computerized systems.
- Designing the structure of a monitoring system of the dangerous work places in order to prevent work accidents.
- Designing a hardware and software model for the monitoring of the degree of safety of the dangerous work places.

### **5. Relevance**

The research for the elaboration of the thesis materialized by the realization of an innovative product, new in Romania, consisting in a distributed system, open scalable, for monitoring the dangerous work places, preventing the appearance of accident risks. The system contributes to reducing the technological risk, ensuring in real time the management of the dangerous situations by anticipating the risks.

At present date the employers must assess the risks for accidents and professional diseases for the work places within the companies they administer, and to keep these risks under control– an activity which requires specialized and experienced staff. With the solution proposed in the thesis we can ensure a relatively easy control of the risks, easy to administer and especially accurate and efficient.

### **6. Methodological and theoretical-scientific support**

In order to perform the research have been consulted books, invention patents, doctorate theses, magazines, scientific works, internet sites and relative regulations in the areas of work safety and health and informational technology. The research

## **7. Scientific novelty of the obtained results**

The character of novelty in the area of work safety and health is given by the method of risk evaluation proposed in this thesis, which is based on the theory of the Bayes networks, as well as the model realized for the safety monitoring system, which uses the latest hardware components and software techniques.

## **8. Applicative value of the work**

The work safety monitoring system can be used for improving the degree of security in work in a large range of cases, especially as a perimeter guard for the work equipments which have not been projected with protection elements, or in the areas where physical elements of protection cannot be installed. The applicability of the results obtained in the thesis has been demonstrated by the experiments done in the commercial societies CIB PET SRL Craiova and SC ALENYS SRL Craiova.

## **9. Disseminating the results**

The basic results obtained in the thesis have been exposed and discussed during nine international symposiums, a meeting, two specialized magazines, a research report and a patent application.

## **10. Publications**

The main results of the thesis, consisting in a number of 14 scientific works, have been published in specialized magazines or in the volumes of national and international conferences, as well as a research report and a patent application.

## **11. Thesis's volume and structure**

The thesis contains a number of 216 pages and is structured in five chapters in which the results of the research are presented, accompanied by 55 figures, 15 tables, 15 relations, a chapter of final conclusions and contributions, a bibliographical list which has 107 bibliographical positions, out of which in 11 positions I am the main author, and in other 3 of them, coauthor and two annexes..

In the first chapter of the thesis, called *The Analysis of the Methods of Evaluation and of the Means of Monitoring the Accident Risks*, are classified and analyzed the

current methods for the identification and evaluation of the accident and professional diseases risk factors, and every method is described and the advantages and disadvantages of its use are analyzed.

All the methods require more or less the intervention of the human factor. Thus, one of their common traits leads to the most important restraint – man. This restraint consists in the fact that the methods are subjected to a degree of subjectivism which is in direct proportionality with the capabilities and the experience of the individual, in his limits of time and reaction. By implementing the systems for monitoring and evaluating in real time, it is desired to minimize or eliminate as much as possible the action of the human factor and to ensure a continuous monitoring.

In this chapter I have also analyzed the main means or special equipments which can be used in order to realize a complex system of safety monitoring, as well as for the purposes for which they were designed.

In the second chapter, entitled *Contributions regarding the Risks Evaluation Methods*, we proposed a manner so as to improve the evaluation methods previously presented, by conceiving a method which can be implemented in the computerised systems, which makes use of the Bayesian theory. Within this method, the evaluation concept is extended to the possibility to avoid an accident by removing, from the very beginning phases, in accordance with the analysis of the labour incidents dynamics.

In the third chapter, called *Architectures for Safety Screening*, we proposed a series of methods of achieving screening systems considering the current patterns of screening computerised systems and subsystems designing operating in real intervals. They have been considered compulsions with regard to the limited hardware resources, the operating, safety and safety running environment that they have. It is analyzed the safety and the safety running of a screening system having a certain number of identical sensors.

The fourth chapter of the thesis entitled *Contributions regarding the screening system structure of the hazardous work places* consists in the personal contributions brought with regard to the structure of the screening system and its subsystems.

One of the major contributions refers to the safety video screening subsystem which has the role of providing alarm triggering in case it detects if a certain dangerous area, as defined by the user is trespassed, behaving as a virtual protection fence. This subsystem is based on acquiring images directly from a screening camera, or by a

network from a screening server. Another contribution which must be stressed out refers to the screening subsystem of the working environment which checks if the most likely possibilities for a dangerous situation to occur are met and which might end up in an accident to occur because of the working environment conditions. In this chapter it is also proposed the architecture of a screening system of security of travellers by and workers on a railway vehicle, an intelligent, effective and safe one, by which by means of the images analysis techniques a dangerous situation can be recognised. If persons are subjected to dangerous situations, the system detects this and takes the required measures of warning or alarm triggering.

The fifth chapter of the thesis, entitled *Experimental results achieved by the screening system of the dangerous work places*, includes conclusions achieved following experimentation with the screening system, made both under the laboratory conditions and under real conditions, based on which we tested and proved the abilities and use of this screening system. An important aspect which must be mentioned is that experiments to test the safety video screening subsystem under real conditions have been performed at trading companies which in the future can become the beneficiaries of this system because the work equipments where screening took place are not endowed with protection systems, by applying this system increasing the workers' protection level.

The sixth chapter, *Final conclusions and personal contributions*, finishes the thesis by presenting the personal conclusions and a summarising of the theoretical, software and experimental contributions that we bring by this work. In the end of the chapter there are presented the possibilities of extending the screening system by the applicability it can provide regarding the working personnel training, depending on the real situation.

## **12. Personal contributions**

### ***12.1. Methodological contributions***

Within the thesis there have been gathered, ranked and structured the main evaluation methods of the accidents and professional sickness risks. We have started from the evaluation principles and based on them we have ranked the evaluation methods. For each method we have identified the advantages they offer but also the weak points that it has. We have identified and ranked the main means of detection for the

workers' safety. For each type there has been presented the purpose for which it was achieved and its applicability method.

### ***12.2. Theoretical Contributions***

In the field of the risks evaluation methods we have proposed as a necessity in the field the use of the Bayesian networks in evaluating the professional risks. Following the analysis of the work incidents dynamics we have considered that the undesired events can be avoided by taking steps from the very start phases of the risk occurrence, by providing a judgement based on the Bayesian theory. We have identified and proposed the judgment patterns based on the Bayesian theory both for the analysis of a system and for a safety screening system, considering also aspects connected with the cost-risk analysis.

We have proposed a method to evaluate the hazard risks based on the Bayesian networks, which can be implemented by means of the computerised technology, and by which it is provided an evaluation in real intervals of the risks by providing a permanent screening of the work places.

The main results of the research have been published in a total number of 14 scientific works forming part of the volumes of national and international lectures such as the *International Symposium regarding Labour Security and Health in Petrosani*, *The European Week of Labour Security and Health*, *The University of Craiova Annals*, or the magazine *Speciality Objective in the Labour Security and Health Field*, edited by the Ministry of Labour.

### ***12.3. Hardware Contributions***

Considering that the safety screening system is a system running and providing protection to workers in real intervals, we have identified and proposed architectures patterns used in designing the system in real intervals, considering mainly the compulsions related to the safety running and safety theory of the real intervals systems. For each architecture pattern we have analysed the advantages of it being used, considering the aspects related to the running safety that they provide and the quality of the service.

The architecture of the screening system has been carried out as an assigned system made up of specialised screening, acquisition, and communication equipments and by software specifically designed for the management of this system. There have

been analysed and selected detection and acquisition equipments, so as to provide the lowest cost possible for the system, so that its implementation can be viable. The system includes two screening subsystems, versatile and configurable so that they can best adjust to the real requirements and compulsions from the work places they screen.

It has been proposed the architecture of a system so as to screen the travellers and the working personnel's security as a subsystem of an intelligent vehicle for the safe and effective transport of the travellers which is based on the analysis of the video images and forms recognition. This increases the security level of the classical systems of video surveillance by the fact that it recognizes a dangerous situation and it takes the required security steps, depending on the procedures adopted by the railway operator.

#### ***12.4. Hardware and Software Contributions***

It has been carried out the safety video screening subsystem by using a video camera which already exists in order to supervise production or by installing a video camera dedicated to this purpose, connected locally or by means of a computer network on which the screening software is run. This screening subsystem provides surveillance of a dangerous area from a work place and if that dangerous area is trespassed it triggers an alarm. This subsystem performs also a detection of the illuminating level in the working environment, if the illuminating conditions become improper, generating an alarm signal.

It has been achieved the screening subsystem of the working environment which uses the assigned technology and which allows the screening of one or several working environment factors such as temperature, moisture, carbon monoxide concentration and respectively the work equipment condition which in different combinations might lead to occurring a hazardous situation and respectively to taking place a hazardous phenomenon, resulting in an undesired event. The working environment screening subsystem is assigned and in this regard it can screen simultaneously several areas of the working environment. Reading of the sensors figures is performed by means of the acquisition specialised equipments to which they are connected, the equipment condition being displayed on the process computer or checked with a micro-contact. This subsystem processes the acquired data based on a judgment pattern built by means of the Bayesian networks, allowing an evaluation within real intervals of the real and actual

situation of the working environment and counting the occurrence probability of an accident by applying the inference mechanism.

### ***12.5. Software Contributions***

It has been carried out the software application of the safety screening system by using latest generation technologies and the Visual C# programming environment from the Visual Studio 2008 software development applications sequence. This programming environment allowed the development of the application so that it can be useful, quick, easy to use, having an easy graphic interface, as well as to provide the easy modification and subsequent development of the program. The application has a wide frame of reference, being used both within programs having applicability in the computerized imagistics and images analysis, and within those addressed in computer networks communications, or data gathering from specialised equipments.

### ***12.6. Applicative Experimental Contributions***

Experiments have been performed both under laboratory conditions and under real ones, and based on them we have run tests and have proved the abilities and usefulness of this screening system.

The laboratory experiments had as purpose to simulate real conditions in the working environment screening subsystem running so as to prove the method by which it interprets the figures and it establishes the occurrence probability of a hazardous event depending on the working environment decisive factors.

Experiments to test the safety video screening subsystem under real conditions have been performed with SC CIB-PET SRL and SC ALENYS IMPEX SRL in Craiova, potential beneficiaries of the functions of this system in the future, since the work equipments which have been screened are not endowed with protection systems, applying this system meaning an improvement of these systems and inferentially the increase of the workers' protection level.

We have drawn up and submitted with the State Office for Brands and Patterns – OSIM, a patent application of the work places screening system method, proposed by this thesis, this representing one of the first steps in the applicative development of this system.