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RISK ASSESSMENT METHODS

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Summary: Creation of safe and good living and working conditions (reduction of injuries, professional diseases and disabilities, fire elimination and prevention, emergency management, environmental protection, etc.) is accomplished through application of diverse and complex preventive measures, which help prevent and eliminate occupational and environmental risks of different nature and character.

The most important methodological step for adequate risk management is risk assessment. Risk assessment is an analytical instrument for designating risk factors to human health or material and natural resources, as well as for determining priorities for risk reducing measures.

An analysis of such a complex issue inevitably leads to the emergence of numerous fields of research, both in our country and in the rest of the world. Proper consideration of the issues in these fields will result in optimal solutions. Nevertheless, some globally very highly developed approaches are underutilized in our country and even the widely accepted systemic approach to research is insufficiently used, which necessarily entails methodological reorientation in domestic research in order for it to get closer to global developmental tendencies. Therefore, the study of risk in complex systems requires a synergetic approach based on multidisciplinary principles as this is a complex issue that requires a comprehensive analytical and prognostic assessment of the actual and expected state in occupational and environmental risk management.

The basic idea in conceiving the content of this publication was to present years of research by the authors in the field of system safety and risk and to gather and systematize in one place the most significant methods for occupational and environmental risk assessment. In keeping with this idea, the content is presented through ten chapters.

In the first chapter, *Basic Risk Related Terminology*, the authors' research interests are focused on determining and defining basic terms and concepts used in risk theory. The basic risk terminology – hazard, risk, emergency, accident – is presented, as well as definitions and classifications of risks, emergencies and accidents. Without any pretension of being overly comprehensive, the authors' intention was to show the fundamental distinctions between the aforementioned terms in order to establish a necessary theoretical background for the subsequent part of the publication, which pertains to risk management.

Chapter two, *Risk Management – Approaches and Characteristics*, develops the concept of occupational and environmental risk management and analyzes in detail the approaches (contexts, frameworks) of risk management globally and domestically. As indicated by the literature, the initial steps for studying and implementing risk management were made in Australia, the USA, and the UK. The final step of this research is the analysis of risk management based on the ISO 31000:2009 standard. Risk management systems by all means reflect the socio-economic conditions of communities in which they are implemented, which is why variations among risk management systems in different countries are considerable but expected. The variations are caused by economic development, legal systems, political and territorial organization, social systems, and natural features, but also by other objective and subjective needs and possibilities.

The third part of the publication, *Basic Stages of Risk Management*, elaborates on the fundamental theoretical and methodological postulations of risk management. In fact, the authors consider and conceptually shape the basic stages of risk management, which aid the process of defining and establishing a unified methodology for risk assessment and management. The stages are presented by means of an algorithm designed as a result of years of work on this issue.

Occupational and environmental risk assessment is based on continual application of the analytic-synthetic methodological approach because it provides stable balance of the system, which is exposed to constant changes in operating conditions and numerous other influences. Since risk assessment is the foundation of risk management, it is necessary to be acquainted with the methods that can be used for this purpose.

According to the data they use, risk assessment methods can be qualitative, quantitative, and combined. They are divided into probability assessment and consequence assessment methods. The purpose of probability assessment methods is to identify and quantify areas where risk can potentially occur, whereas the purpose of consequence assessment methods is to assess negative consequences and their potential effects, as well as to describe possible safety measures for eliminating those effects.

According to the ISO 31010:2009 and considering the steps involved in risk assessment, the methods are classified into methods for risk identification, methods for risk analysis, and methods for risk assessment. The choice of risk assessment method depends on: the capabilities of the method itself; the complexity of the process;

organizational level and amount of experience related to the process; the degree of indeterminacy of the problem, i.e. the quality of available information; the resources necessary for the implementation of risk analysis and assessment; the depth of analysis; etc.

According to the aspect of application, risk assessment methods are classified into methods for risk assessment of technical systems, methods for human reliability assessment, and methods for accident analysis, and methods for management analysis. Each of these groups of methods is elaborated in more detail in separate chapters.

The fourth chapter, *Methods for Risk Assessment of Technical Systems*, covers methods used to identify energy in analyzed systems, to identify hazards and their operational elimination, to identify the type of failure and potential effects on the system, to design a graphoanalytic model of technical system failure, or to model an undesired event through event sequence identification. The methods in this group on which the authors are especially focused are the following: Energy Analysis, Hazard and Operability Analysis, Failure Mode and Effects (and Criticality/Detection) Analysis, Fault Tree Analysis, and Event Tree Analysis.

Analysis of referent literature suggests a conclusion that the human factor is the dominant cause of risk events. Yet, even when the human factor is not dominant, the authors agree on the role and importance of human errors in assessing hazards and risks in those systems to which these terms usually pertain (in hi-tech industrial systems, including nuclear, chemical, electric power, and similar plants). Beginning with these facts and findings, the fifth chapter, *Methods for Human Reliability Assessment*, contains human error analysis and an overview of methods for human reliability assessment with the purpose of classifying, identifying, quantifying, and reducing human errors. The chapter also contains a detailed description of the Human Error Assessment and Reduction Technique.

Traditional methods for accident analysis analyze only accident reports, without establishing any correlations between relevant factors of accident causes and effects, and therefore cannot propose adequate solutions for the provision of safe work of man-operator. Accordingly, the sixth chapter, *Methods for Accident Analysis*, deals with modern methods for accident analysis: Safety Function Analysis, Deviation Analysis, Change Analysis, Job Safety Analysis, and the Complex Method for Assessment of Overall Hazard of an Accident. The purpose of these methods is to identify and analyze deviations that may lead to accidents, to identify parameters that determine safety levels and changes that may increase system risk, and to calculate hazards of accidents caused by the operation of technological processes, by the human factor, and by the environment.

Organizational and management activities in complex systems are not always properly coordinated and their harmonization poses a big problem. The methods oriented towards organizational and management activities determine e.g., how a system is designed, how operational activities are being implemented, who works in the plants, how a system is managed, and which safety measures are in place. The quality and proper orientation of these activities is of paramount importance for the analysis and assessment of hazards and the ways of risk control. The chapter *Methods for Management Risk Assessment* is the seventh chapter of the publication. It describes methods for risk assessment of management activities, whose aim is to objectively verify whether the implementation of management systems for quality, environmental protection, and occupational safety and health complies with international standards. These methods are also used to identify organizational and management errors by analyzing accidents with logical diagrams and by integrating partial management systems into a single management system. Analysis of this complex organizational and management issue employs a variety of techniques, tools, and systems, and the authors opted for a comprehensive definition and review of the following ones: Safety, Health and Environmental Management System, Audits, Management Oversight, and Risk Tree.

Environmental protection is becoming a priority of almost every organization. Implementation of the eco-management system and of the legislation of developed countries requires a proactive approach to environmental protection in all its aspects. Important tools for the implementation of an efficient and effective eco-management system are Life Cycle Analysis and Exergetic Life Cycle Analysis, which represent *Methods for Environmental Risk Analysis* (Chapter Eight). The purpose of these methods is to assess the environmental properties of products and processes and to summarize their possible environmental impact in each life-cycle stage, from the extraction of raw materials, through production, distribution, and use to their disposal.

The ninth chapter, *Case Studies*, covers the practical application of the most frequently used risk assessment methods. The common feature of each of the methods presented is that the use of adequate information support increases implementation efficiency, process transparency, and generation of relevant information for teams, all for the purpose of adequate risk assessment and support of decision making regarding occupational and environmental safety and improvement.

In the tenth, and final, chapter, entitled *Concluding Remarks*, the authors emphasize the importance of the analyzed methods and their contribution to risk assessment and also highlight the value of the synergy of those methods through various stages of risk assessment. Based on years of research, the authors reach an undeniable conclusion that only synergetic implementation of risk assessment methods can provide hazard identification in the studied systems, risk assessment of complex systems, and introduction of adequate measures to reduce risk to an acceptable level.

Annotation: Upon decision No. 03-87/4 of the Academic Coouncil of the Faculty of Occupational Safety, University of Nis, the publication titled “Risk Assessment Methods” has been categorized as a Monograph of national significance.