

READINESS OF LARGE INDUSTRIAL FACILITIES FOR EMERGENCY SITUATIONS - THEORY AND PRACTICE

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Abstract In today's industrial environment, effective risk management and emergency preparedness are crucial for protecting lives, property, and the environment. Large industrial facilities, due to their size and complexity, are particularly vulnerable to accidents and natural disasters. This paper analyzes both theoretical and practical aspects of emergency readiness in such facilities, focusing on prevention, preparation, response, and recovery. It includes a review of key international frameworks like the Hyogo and Sendai Frameworks, which guide disaster risk reduction efforts. The legal framework in the Republic of Serbia, including the Law on Disaster Risk Protection and Emergency Management, is also discussed. Special attention is given to planning documents such as disaster risk assessments and protection plans, particularly for SEVESO facilities. Despite their existence, many facilities lack practical implementation and training, leading to uncoordinated responses. Through real-world case studies—including floods, fires, earthquakes, and the COVID-19 pandemic—the paper identifies common failures and highlights lessons learned. Recovery strategies and the importance of proactive investments in safety are examined to support the concept of rapid response with minimal consequences. The paper concludes by emphasizing the need for ongoing improvements and integration of theory and practice to enhance preparedness and resilience in the industrial sector.

Keywords: Industrial security; emergency situations; international and legal frameworks; training; crisis management.

1. INTRODUCTION

The history of human society is full of numerous dramatic events as well as devastating catastrophes that leave their mark on the Earth's surface and in human emotions. Climate change is becoming more evident in the modern world. Across the globe, meteorologists are raising concerns among the population about significant climate changes in the next 100 years. This will result in a large number of natural disasters such as floods, strong winds, droughts, and similar events [1]. The main cause of their occurrence lies in humanity's limited knowledge about the surrounding world, which in many cases does not allow for the prediction of all the consequences of numerous scientific and technological projects and solutions. Seismic, technological, and environmental hazards hinder the sustainable development of society as a whole. Their occurrence in one region can cause damage in another and vice versa. No country, regardless of its economic, technological, and social level, as confirmed by current events worldwide, is immune to them. Numerous risks and dangers of accidents, natural disasters, incidents, and other forms of destructive measures affecting people, animals, nature, material goods, and the environment cannot be ignored by any country. Natural disasters cause enormous damage to a country's economy (amounting to hundreds of billions of dollars annually) and are especially dangerous for the agricultural sector, as they are directly

dependent on it. Human casualties from such disasters are frequent in affected areas, and more attention must be paid to them in the future, especially when it comes to preventing such disasters. These disasters can occur in both peacetime and emergency situations. In the context of all the above, we conclude that security is one of the most important aspects of modern society, and industrial security is a key segment of this system. Industrial plants, due to their complexity and scale, pose potential risks in the event of accidents, natural disasters, or other emergency situations. Risk management and emergency preparedness have become imperative to maintain the safety of people, the environment, and property [2, 3-4]. This paper analyzes the theoretical and practical aspects of the readiness of industrial facilities to act in emergency situations, with an emphasis on prevention, preparation, response, and recovery. According to research, in the last ten years, there has been a 15% increase in industrial accidents, and economic losses due to emergencies are estimated at over \$200 billion annually worldwide. This paper deals with the readiness of industrial facilities to respond to emergency situations, aiming to raise awareness among managers, engineers, decision-makers, and all other interested parties about the importance of preventative measures in the safety of industrial complexes.

2. INTERNATIONAL REGULATION

International frameworks for risk management and emergency response represent a fundamental component of global industrial safety strategies. Among the most significant are the Hyogo Framework [5] for Action and the Sendai Framework for Disaster Risk Reduction [6]. These documents establish essential principles for reducing disaster risk and enhancing response mechanisms to both natural and technological hazards. They underscore the critical role of preventive measures, systematic preparedness, and the ongoing development of comprehensive risk management practices.

These documents provide guidance for risk reduction and improvement of emergency response through the development of laws, strategies, and methodologies that industrial facilities should implement to protect people, property, and business operations, both globally and within the territory of the Republic of Serbia. A new body established under the auspices of the United Nations, in coordination with the positions taken at the Sendai Conference and with the UN Office for Disaster Risk Reduction, is an intergovernmental expert working group. The task of the group is to assist at the expert level in the application of scientific knowledge and methods in the process of reducing the risk of various forms of emergency situations. In addition to the UN, several other organizations are active globally, most notably UNESCO, FAO, and ILO. The International Atomic Energy Agency (IAEA) plays a particularly important role, with numerous conventions and protocols adopted under its auspices that regulate various aspects of conduct and responsibility in the matter of nuclear energy.

The Hyogo Framework for Action was adopted at the 2005 World Conference on Disaster Risk Reduction in Kobe, Hyogo, Japan. The scope of the framework for action includes incidents caused by natural disasters, as well as related environmental and technological hazards and risks. The Sendai Framework was adopted in March 2015 at the Third United Nations World Conference on Disaster Risk Reduction in Sendai, Japan, and provides impetus for further global activities by countries under the Hyogo Framework for Action. Building on the Hyogo Framework, the Sendai Framework introduces several innovations, including:

1. An emphasis on disaster risk management in relation to disaster management.
2. The prevention of new risks.
3. The reduction of existing risks and increased resilience.
4. The engagement of society as a whole and all government institutions (Legal, Strategic, and Institutional Framework for Disaster Risk Management, 2015).

To achieve the global goals, set out in this document, all countries participating in the conference must adhere to certain principles. These principles vary depending on national circumstances, applicable national regulations, and the international obligations and responsibilities of each country [7].

3. BACKBONE FRAMEWORKS IN THE REPUBLIC OF SERBIA

In the Republic of Serbia, the legal framework for risk management and emergency situations is defined by the Law on Disaster Protection and Emergency Management (Official Gazette 87/18) [8] and its implementing regulations. These regulations require industrial facilities to develop disaster risk assessments, protection and rescue plans, and accident protection plans, which are essential for the effective management of emergency situations. However, practice reveals a gap between these theoretical requirements and their practical application, resulting in insufficient preparedness and coordination in real situations. The implementation of these standards also faces several challenges, including a lack of resources, inadequate employee training, and the absence of a systemic approach to crisis management.

The aforementioned law aims to regulate measures in specific emergency situations (fire, flood, chemical accidents, technical and technological accidents, etc.) regarding the use of protective and rescue resources, defining emergency management, and other essential elements for a functioning protection and rescue system. However, its practical application remains a concern. Our experience working with and communicating with numerous entities in transnational industries has shown that the legal framework is similar or less developed in other countries where they operate. These industries increasingly recognize that, beyond legal compliance, they must take internal measures to enhance preparedness for an adequate response to any emergency situation or event.

4. PLANNING DOCUMENT FOR ACTION IN EMERGENCY SITUATIONS

Planning documents, such as risk assessments and protection and rescue plans, are crucial for effective emergency management. For higher-tier SEVESO facilities, the local government where the plant is located is required to develop an External Emergency Plan for Major Accidents. However, although these documents are mandatory, many plants do not test their practical application. Specifically, these documents identify the individuals who will play specific roles in protection and rescue, namely:

- Commissioners and Deputy Commissioners of Civil Protection.
- The Emergency Management Team.
- The Emergency Response Team.

- In the event of an accident, the plant operators.

Experience demonstrates that these appointments frequently remain only at the planning stage. In an actual emergency, significant disorganization arises from the lack of timely reaction and resource mobilization by those responsible. The root of this problem lies in several factors, including inaction and lack of support from plant management, insufficient material resources for adequate preparation, and inadequate education and awareness. The absence of regular drills and training frequently results in chaos and panic. This chaos and panic are the antithesis of what planning aims to achieve, leading to substantial losses and a slow return to normal operations.

5. CONTINUOUS TRAINING AND RAISING READINESS

One of the key aspects of emergency preparedness is the continuous training of employees and management. Practical exercises and simulations of emergency situations enable better preparation and coordination. However, many companies neglect this segment, focusing mainly on documentation. This approach can lead to an inability to navigate real-world situations, which can have disastrous consequences for people and property.

A systematic approach to training and exercises significantly contributes to better organization and damage reduction during emergency situations. According to the European Agency for Safety and Health at Work, companies that regularly organize simulations have a 40% lower number of accidents compared to those that rely only on documentation [9]. This is a model that needs to be adopted in the field of emergency situations. The training itself should be organized into two segments:

1. Theoretical preparation

Familiarization with the obligations, provisions, and rights of all subjects, both those imposed by the law and those assumed from planning documentation. It is crucial that each person knows their clear role and tasks, including how and to whom they should report in the event of an emergency or if they observe changes that could lead to one. A key component of theoretical preparation is learning from past incidents and analyzing previous harmful events.

2. Practical preparation

While various practical preparation methods exist, we recommend unannounced exercises that simulate real situations. Evacuation drills, sheltering drills, and exercises focused on the safe relocation of employees are just a few examples. In addition to rescue exercises, ICT systems play a significant role in today's digital era, especially in large industries, so it is crucial to test employees in this system. Testing should evaluate the speed of business continuity transfer to a geographically dispersed location, the speed of response to malicious software, and similar scenarios. Research indicates that individuals who have survived a particular type of emergency (e.g., earthquake, flood, explosion) are significantly more receptive to new knowledge and skills related to prevention. Virtual reality (VR) offers a powerful tool for this. As a mandatory part of preparedness, VR-based exercises should be implemented, providing a realistic user experience that simulates fear and panic, thus offering a true assessment of individual readiness to act according to the planning documentation.

In addition to the training of employees and management at individual companies, a key to effectively addressing this issue lies in continuous education that begins from an early age. Educational activities carried out through preschool and school programs are effective measures that emphasize the importance of disaster risk reduction while transferring this knowledge to their families as we work with children. The number of natural and technological disasters is constantly increasing, with increasingly serious consequences for people and their property. Therefore, all preventative measures must be taken to reduce the risk of disasters. Education about these risks is one of the most vital preventative measures [10].

6. PRACTICAL EXAMPLES

Case studies reveal that many industrial facilities face similar challenges in emergency situations. For example, during the floods in Serbia in 2014, many factories suffered significant material losses due to insufficient infrastructure resilience. During the COVID-19 pandemic, many companies faced challenges in crisis management and the adaptability of work processes. Unpreparedness led to substantial losses, and transnational companies reported a wide range of different reactions at each isolated location, significantly hindering their ability to centralize crisis and risk management. These examples underscore the need for continuous improvement of emergency preparedness systems and greater integration of theoretical and practical aspects.

An analysis of specific examples illustrates how large industrial companies globally and in Serbia have reacted to crisis situations [11]. These include:

- *Floods* - many factories experienced problems with infrastructure resilience and flood protection.
- *Earthquakes* - poor structural resilience led to significant material losses.
- *Fires* - failure to follow safety protocols often caused serious accidents.
- *COVID-19 pandemic* - weakened business continuity and highlighted shortcomings in crisis management.

Table 1. Examples of major industrial accidents in the past 10 years [12-14].

Industry Event	Consequences
Floods in 2014 in Serbia	€1.7 billion in damage
Explosion in Beirut in 2020	218 dead, \$15 billion in damage
Fire at the Bambi factory in 2024	Millions of dollars in damage, production shutdown, which has been going on for 8 months
COVID-19 in industry	Production decline by 20-30%, layoffs

Analysis of these cases helps to identify weak points and improve strategies for future crisis situations.

7. CONCLUSION

The security system that is being formed, and whose function includes readiness for emergency situations among other things, must be dynamic and continuously improved. Industrial safety and emergency preparedness require constant advancement through the integration of theoretical and practical approaches. Key success factors include integrating international and national standards, developing planning documents, conducting regular training and exercises, and analyzing real-world

incidents to learn from past experiences. Only a comprehensive approach can minimize risks and ensure an effective response to emergencies.

This paper offers valuable information and recommendations for managers, engineers, and decision-makers in the industry, aiming to raise awareness of the importance of prevention and emergency preparedness. Continuous learning and practical application are essential for achieving a high level of safety in industrial complexes.

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