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Alena Oulehlová

A VESZÉLYES TEVÉKENYSÉGEK KOCKÁZATKEZELÉSE A CSEH KÖZTÁRSASÁGBAN

Absztract

Jelen tanulmány a Csehországban alkalmazott katasztrófavédelmi kockázatelemző módszerek és az eljárások alkalmazási tapasztalataival foglalkozik. A cikk első része a Cseh Köztársaságban 2016-ban elkészített veszély elemzés eredményeit mutatja be. A veszélyelemzés 22 kockázatot azonosított, melyből 10 technológiai jellegűnek mondható. Ezek a kockázatok az emberi veszélyes tevékenység következtében jelentek meg. Minden egyes elfogadhatatlan technológiai kockázat esetében megállapították a kockázat kialakulásának folyamatát, a kockázatelemzés módszereit, és a kockázatkezelés folyamatát. A tanulmány rámutat a kockázatkezelési eljárás során keletkezett hibákra is. A cikk megállapítja a veszélyes tevékenységek kockázatkezelésének szükségességét.

Kulcsszavak: Csehország, veszélyes tevékenység, kockázatelemző módszerek, kockázatkezelés

RISK MANAGEMENT OF HAZARDOUS ACTIVITIES IN THE CZECH REPUBLIC

Abstract

The article deals with the application of risk analysis methods and applied risk management procedures in the Czech Republic. The first part of the paper describes the procedure and results of the threat analysis carried out for the Czech Republic in 2016. The threat analysis identified 22 risks, 10 of which were technogenic anthropogenic. These risks are related to hazardous human activities. Sources of the risk, used methods of risk analysis as well as the assessment procedure, if implemented, were stated for each unacceptable technogenic risk. The paper points out the defects which were identified within the application of risk management. The results of the article show the necessity of the application of risk management for the needs of hazardous activities management.

Keywords: Czech Republic, hazardous activity, risk analysis methods, risk management

1. INTRODUCTION

With the development of human society, the production and consumption of products (commodities or services), including all accompanying procedures, grow. Production as well as consumption processes are not independent processes separated from natural processes; on the contrary, they are firmly linked to nature through substance and energy flows. The impacts of the production and consumption processes on population, property, the environment as well as ecosystems increase both qualitatively and quantitatively. Intentional and unintentional anthropogenic disasters with large impacts are at the height of these unfavorable influences (e.g. Seveso, Bhopal, Chernobyl, Three Mile Island, Baia Mare, Exxon Valdez, Ajka).

In the past, from the point of view of reducing anthropogenic disaster risks, it was possible to observe a more reactive approach to dealing with disaster consequences. Extensive anthropogenic disasters have contributed to learning from trials and errors and tightening conditions of operation of both existing and new facilities. Gradually, the approach turned from reactive to active with risk management being its necessary part.

Risks associated with anthropogenic activities will not be eliminated in the future and it can be assumed that in connection with society evolution, their diversification, character and importance will change. The trend is already noticeable, for example by the arrival of information and communication technologies or by the application of Industry 4.0. Some risks have been almost completely eliminated or at least reduced whereas others are identified in terms of intensity and impact. The state emergency system must implement the disaster risk management results into its management system by applying appropriate tools.

2. RISK ASSESSMENT FOR THE CZECH REPUBLIC

A key issue in terms of hazardous activities is to identify what falls under these activities, that is the identification of sources of danger. From the point of view of an individual, the so-called individual risk, hazardous activities are perceived completely differently than within the social risk. Crisis management authorities must be primarily concerned with ensuring safety of society as a whole.

With regard to the dynamism of the environment and the fulfillment of the United Nations requirements, it is essential that the main responsibility for risk management lies with the central government. Governments must decide what degree of risk they are willing to accept and what tools they will use for risk control [1]. For this purpose, the public and private sector create crisis management authorities at central and local levels and via legislation, they set requirements for risk prevention, minimization and monitoring as well as preparedness and reaction.

The first requirement for an overall risk assessment in the Czech Republic was defined in the Concept of Population Protection until 2020 with the outlook to 2030 [2]. The deadline of the task was by the end of 2016. The risk analysis was divided into two stages – screening and scooping of the risk. Within the screening, the risk identification, risk assessment and determination of the risk acceptance were performed. Unacceptable risks identified in the screening were subjected to a detailed analysis, that is the scooping of the risk. With respect to general stages of risk management, the ČSN ISO 31 000 'Risk management – Principles and guidelines' standard was applied [3].

2.1 Risk Screening

Risks have been identified based on brainstorming of fire brigade experts and representatives of crisis management authorities at national level. The identified risks were assessed for the probability of occurrence and impacts according to Table 1. A risk register containing 72 hazards in the area of nature threats (abiotic, biotic, cosmic) as well as anthropogenic hazards (technogenic, sociogenic, economical) has been created for the territory of the Czech Republic.

Table 1 Probability and consequence criteria for risk screening

QUANTITATIVE INDEX	PROBABILITY		CONSEQUENCES	
	Qualitative indicator	**Verbal description**	**Qualitative indicator**	**Verbal description**
1	Little probable	There is almost only a theoretical possibility.	Low	Little local impact on the lives and health of people, property, the environment.
2	Probable	It is possible, a rare occurrence.	Significant	Greater impact on the lives and health of people, property, the environment of a regional character.
3	Very probable	Frequent occurrence.	Catastrophic	Extensive impact on the lives and health of people, property, the environment as well as economic or social stability of national significance.

The following formula (1) has been used for the risk assessment:

$$R = P \times N \quad [1]$$

R risk

P probability

N consequences

The level of risk acceptance for the screening phase was set at 4. Risks with a value of 4 or higher were ceded to the risk scooping. 21 hazards reached a risk level of less than or equal to 3 and were not further addressed. 49 hazards were subjected to the risk scooping. Two risks were unacceptable for their impact degree. The security breach of critical information infrastructure and the threat of a major disruption of the state's financial and foreign-exchange economy were among the risks that avoided the risk scooping. Table 2 presents an overview of identified anthropogenic technogenic hazards including the level of risk which was estimated in the screening phase. It also shows whether the risk, in accordance with the set reference level of the risk acceptance, was ceded to the risk scooping.

Table 2 Identified anthropogenic technogenic risks in the risk screening phase for the Czech Republic [4]

Risk	**P**	**N**	**R**	**Risk scooping**
leakage of hazardous chemicals during transport	2	2	**4**	**yes**
leakage of biological agents and toxins during transport	2	2	**4**	**yes**
leakage of radioactive material during transport	2	1	**2**	**no**
leakage of dangerous chemicals from a stationary facility	3	2	**6**	**ye**
leakage of biological agents from a stationary facility	2	2	**4**	**yes**
leakage of radioactive material from a stationary facility	2	3	**6**	**yes**
fire in a tunnel	2	2	**4**	**yes**
fire in a built-up area or industrial area	2	2	**4**	**yes**
explosion in a built-up area or industrial area	2	2	**4**	**yes**
serious accident in road transport	2	2	**4**	**yes**
serious accident in air transport	2	2	**4**	**yes**
serious accident in rail transport	2	2	**4**	**yes**

Risk	P	N	R	Risk scooping
serious accident in domestic water transport	2	1	**2**	**no**
accident in underground structures	2	1	**2**	**no**
accident in the subway	2	2	**4**	**yes**
major disruption of heat supply	2	2	**4**	**yes**
major disruption of gas supply	2	2	**4**	**yes**
major disruption of electricity supply	2	3	**6**	**yes**
major disruption of crude oil and petroleum products supply	2	2	**4**	**yes**
major disruption of drinking water supply	2	2	**4**	**yes**
security breach of critical information infrastructure	2	3	**6**	**yes**
disruption of functionality of major electronic communication systems	2	3	**6**	**yes**
disruption of functionality of postal services	2	2	**4**	**yes**
cave-in of old mines	2	2	**4**	**yes**
uncontrolled emergence of mine damp to the surface	2	1	**2**	**no**
mining disaster	2	1	**2**	**no**
mine tremor with an impact on the stability of surface structures	2	1	**2**	**no**
burst of sludge beds and pollution of watercourses – impact on other countries	1	2	**2**	**no**
gas and water eruption when a probe on a gas tank is damaged and when drilling for gas and oil	2	2	**4**	**yes**
finding unexploded ammunition	2	2	**4**	**yes**
explosion in the armory or explosives storage	2	2	**4**	**yes**
major disruption of food supply	2	3	**6**	**yes**
special flood	2	2	**4**	**yes**

2.2 Risk Scooping

At this stage, a semi-quantitative assessment of probability and consequences was used. To determine probability and partial impacts, a scoring scale ranging from 1 to 10 was used. In addition to the numerical value, a verbal characteristic of the impact was assigned to individual scale points. The consequences were calculated as an aggregate quantity expressed by this formula [2]:

$$N = (K_O \times VK_O) + (K_{\check{Z}P} \times VK_{\check{Z}P}) + (K_E \times VK_E) + (K|S \times VK_S) \qquad [2]$$

K_O Coefficient of impact on the lives and health of people

$K_{\check{Z}P}$ Coefficient of impact on the environment

K_E Coefficient of economic impacts

K_S Coefficient of social impacts

The Fuller method was used to determine the weighting coefficient defining the significance of individual impact areas. The calculated weights of individual impact areas are presented in Table 3.

Table 3 Partial weighting coefficients of impacts for determination of consequences [4]

PROTECTED INTEREST	WEIGHTING COEFFICIENT	
	mark	value
lives and health of people	VK_O	0,4
the environment	$VK_{\check{Z}P}$	0,2
economy	VK_E	0,2
social stability	VK_S	0,2

After calculating the consequences, probability of emergence was assigned to hazards and the risk was assessed according to the general formula [1]:. From the point of view of the risk acceptance, these risk levels were set:

- acceptable risk (risk level 0 – 10);
- risks conditionally acceptable (risk level 11 – 29);
- risks unacceptable (risk level 30 and above) [4].

As a result of the risk scooping, 9 risks of natural and 13 risks of anthropogenic origin were identified as unacceptable risks. An overview of the unacceptable risks of anthropogenic origin is presented in Table 4. Since a state of emergency can be declared for these unacceptable risks, a type plan will be prepared for each of them. The plan must be developed in the operational part of crisis plans for procedures necessary for addressing particular types of emergency situations identified by the emergency plan author.

Table 4 Overview of the unacceptable anthropogenic risks in the Czech Republic [4]

No.	Unacceptable anthropogenic risks in the Czech Republic	Risk
1.	Major disruption of food supply	31.33
2.	Disruption of functionality of major electronic communication systems	32.00
3.	Security breach of critical information infrastructure	not analyzed
4.	Special flood	0.67
5.	Leakage of dangerous chemicals from a stationary facility	32.40
6.	Major disruption of drinking water supply	34.07
7.	Major disruption of gas supply	30.33
8.	Major disruption of crude oil and petroleum products supply	30.80

9.	Radiation accident	35.00
10.	Major disruption of electricity supply	45.73
11.	Major migration waves	31.27
12.	Major disruption of the rule of law (including terrorism)	33.60
13.	Major disruption of the state's financial and foreign-exchange economy	not analyzed

Note: Risks with a gray background are unacceptable anthropogenic technogenic risks that will be addressed in the next part of the paper.

Methodologically consistent risk assessments were carried out by fire departments in all 14 regions. Regional fire departments are designated as subjects responsible for keeping an overview of potential risk sources and carrying out risk analyses (Act on Crisis Management). The results of the risk assessment for regions have been taken into account in the development of regional crisis plans.

Can it be said, based on the requirement to create type and crisis plans, that only these 13 unacceptable anthropogenic risks can be regarded as hazardous activities for the whole Czech Republic or its part? With their high probability of occurrence and high impact, the unacceptable anthropogenic risks presented in Table 4 are risks which, with regard to their solution, will require state of emergency declaration. In these cases, there will an increased demand for force and tools necessary for the emergency solution. Also, crisis management authorities will be activated to assign tasks and duties in accordance with the crisis law and crisis documentation. They can be considered as risks with a priority need of prevention, preparedness, response and mitigation/recovery.

All identified risks presented in Table 2 can be considered as hazardous activities because they may likely affect human lives, health, property or the environment, i.e. occurrence of an extraordinary event. In such case, the Integrated Rescue System forces will intervene in a coordinated manner in order to eliminate it. The emergency response procedure will be in accordance with the region's emergency plan, external emergency plan or according to the sets of type activities. In addition, they will declare levels of alarm with regard to the size of the affected area and the number of people at risk.

The regional emergency plan is developed on the basis of an analysis of the emergency occurrence and consequent regional threats. Part of this analysis is an overview of emergency sources, overview of probable emergencies including the possibility of their occurrence, extent and threat to territory of the region [5]. The external emergency plan is developed for nuclear facilities and for objects and facilities where a major accident can be caused by hazardous chemicals and agents [5]. In this case, there is also a connection to a type plan - Leakage of dangerous chemicals from a stationary facility, where the transition from an extraordinary event to a crisis situation is evident. Necessary risk analyses and risk assessments are crucial for the correct development of all these plans.

It is apparent that implementation of identification, analysis, assessment and risk control is necessary for the crisis management authorities with respect to crisis preparedness regardless of the fact whether the risk is acceptable or unacceptable.

3. APPLIED RISK MANAGEMENT PROCEDURES FOR UNACCEPTABLE RISKS

The most crucial question which needs to be asked is whether the identified unacceptable technogenic risks are subject to a detailed risk assessment. On the basis of what obligation is the detailed analysis carried out or is it carried out at all? What methods are used for the risk analysis? The following part of the article brings answers to these questions.

3.1 Major Disruption Of Electricity Supply

The risk of major disruption of electricity supply, so called blackout, is being currently addressed by the crisis management authorities due to the cascading effects of this threat. Blackouts, regardless of where and when they occurred, can be divided into four parts: precondition, origin, chain of events, end [6]. Project Securing the European Electricity Supply against Malicious and Accidental Threats [6] has identified 23 types of nature threats and 12 types of anthropogenic hazards (6 of them arising from accidents and 6 intentional ones). The identified threats are also valid for the Czech Republic. A wide scale of methods for the identification of technological risks as well as human factor failure can be used (Event Tree Analysis (ETA), Fault Tree Analysis (FTA), Failure Mode and Effects Analysis (FMEA), Human Reliability Analysis (HRA), RAMCAP plus All Hazards Risk and Resilience Prioritizing Critical Infrastructures Using RAMCAP plus^{SM} Approach, Monte Carlo Simulation). However, the use of a specific risk analysis method is individual and dependent on the operator of the energy system. Assets in the energy critical infrastructure form a generation part (generator, backup generator, turbine), transmission part (transmission line, power tower, insulators, busbar), transformation part (transformer, switch, voltage control/power factor correction/power flow control device, lightning arrester, circuit breaker, current transformer, control and protective relay), distribution part (distribution line, underground cable, pole, fuse) and information, communication and control systems (cyber equipment, cyber system). Assets can be damaged by the hazard, therefore it is essential to ensure their protection and decrease in such way the potential costs. Vulnerability and impact on the individual parts of the energy critical infrastructure differ in relation to the countermeasures carried out, season of the year and the length and intensity of the effect on the asset. Generally the impact on the energy infrastructure manifests itself as changes in power system topology, operating manner, load level, etc. [6, 7].

3.2 Radiation Accident

Two nuclear power plants (Dukovany, Temelín) in the Czech Republic meet international standards for their operation. In order to secure safe operation, the Probabilistic Safety Assessment (PSA) [8, 9] method is used. The PSA methodology evaluates internal and external risks and consists of phases:

- understanding of the nuclear facility system and gathering relevant data about its behavior during operation;

- identification of initiating events and damage to nuclear facilities;
- modeling systems and chains of events using methodology based on a logical tree;
- assessing the relationships between events and human activities;
- creating a database documenting reliability of systems and components.

When applying PSA, the Event Tree Analysis method has been used for modeling possible accident sequences at Czech nuclear facilities and the FTA [10] method has been used for modeling systems. Due to the possibility of a human error during ensuring safety of a nuclear facility, the HRA method along with Human Performance Evaluation System has been used.

The first PSA level 1 of the Dukovany NPP was completed in 1993. Gradual development of the level 1 PSA model was performed; the study was extended to include other initiating events, such as internal fires, flooding, consequences of a high-energy pipeline break, heavy load drops and external human induced events. Modifications implemented at the nuclear power plant, which included the design changes, equipment replacement and alterations in the operating procedures, have been gradually incorporated into the model. Furthermore, redeveloped analyses (thermal hydraulic, PTS, etc.) have been included and human factor impact has been modeled more detailed. Similarly, low-power modes and refueling outage have been included.

The first results of the level 2 PSA study establishing frequency of the radioactivity release into the environment during severe accidents were handed over to the state regulatory body in April 1998. Level 2 PSA has been processed for full power operation. In 2002, this analysis was updated through new input data based on the actual results of the level 1 PSA model and has been thus incorporated into the Living PSA program. Last update of the level 2 PSA study was executed in 2006.

The Shutdown PSA (SPSA), i.e. the PSA for reactor low-power operation and for shutdown, was developed in 1999. The SPSA results showed that the total core damage contribution during outages is comparable to the contribution during operation at full power. Based on the Shutdown PSA results, new and more detailed emergency guidelines were developed. Some modifications in scheduled maintenance management were also performed.

Further to results of the level 1 and level 2 Living PSA study for the Dukovany NPP, the effort concentrated on a reduction of impact of the most significant accident sequences. Further changes in the design were made, some equipment was replaced and new emergency procedures were developed. All the planned modifications of the power plant units relating to nuclear safety were evaluated, based on the results of the level 1 Living PSA study, and prioritized in terms of reduction of risk. The results of the level 1 Living PSA study have also been used to support the development of new procedures dealing with emergency and abnormal conditions (level 1 Living PSA) and procedures dealing with beyond design basis accidents (level 2 Living PSA). New symptom-based procedures have been then incorporated into the PSA model (in 1998 for nominal unit power and in 2002 for shutdown conditions).

With respect to some differences between the individual units of Dukovany NPP, the PSA model for Unit 1 was modified for other NPP units in order to show their actual state; therefore, the PSA models for Units 1, 2, 3 and 4 are currently available [11].

Table 5 Overview of CDF, FDF and LERF for individual units of Dukovany NPP [12]

	CDF [year^{-1}]	**FDF [year^{-1}]**	**LERF [year^{-1}]**
Unit 1	7.22×10^{-6}	1.13×10^{-5}	1.21×10^{-6}
Unit 2	6.45×10^{-6}	1.05×10^{-5}	1.17×10^{-6}
Unit 3	6.47×10^{-6}	1.06×10^{-5}	1.18×10^{-6}
Unit 4	6.52×10^{-6}	1.06×10^{-5}	1.18×10^{-6}

Core Damage Frequency (CDF)

Fuel Damage Frequency (FDF)

Large Early Release Frequency (LERF)

Extreme snowfall and extreme wind are the biggest contributors to the risk of external events. Seismic PSA has been processed only for EDU1, but its contribution to the risk is not significant. Currently, technical changes which will reduce the size of LERF for external events [12] are prepared.

The first probabilistic assessment of the Temelín NPP Unit 1 and Unit 2 was developed in 1993 – 1996. The goal of the PSA project of the Temelín NPP was on severe accident risks, to understand the most probable accident sequences that may occur at the plant, including their importance, to acquire quantitative understanding of the total Core Damage Frequency and frequency of release of radioactive substances and to establish the main contributors to such releases. The PSA project of the Temelín NPP included evaluation of level 1 PSA at power operation, low-power operation and during outages, as well as the evaluation of risk, fires, flooding, seismic events and other external events. The project also included evaluation of the level 2 PSA. As to events, only the potential risks of sabotage and war were not assessed since the beginning, PSA analyses have been drawn up as "Living" [11]. Living PSA is used to determine the average risk based on the expected failures of systems and equipment. It is regularly updated as necessary to reflect the current state of the design solution and the operational characteristics of the nuclear facility.

The main results of the updated PSA models of Temelín NPP for analyzed list of internal and external initiating events and the Temelín NPP status at the beginning of 2013 represent Core Damage Frequency (CDF) estimation of the Temelín NPP Unit 1 and Unit 2:

- CDF = 1.39.10-5/year for operation at power;
- CDF = 9.28.10-6/year (outage) for all operating conditions of the outage;
- CDF = 7.42.10-6/year for internal fires;
- CDF = 1.35.10-6/year for internal flooding;
- CDF = below 1.00.10-8 for seismic events;
- CDF = below 1.00.10-7 for other external events;
- Total CDF = 3.2.10-5/year for all operating modes and initiating events;
- Total LERF = 4.04.10-6/year (without application of the SAMGs) [12].

Real annual cumulative value of CDF, as a result of Temelín NPP operational configuration risk monitoring, amounts to 1.10 x 10^{-5} for Unit 1 and 1.074 x 10^{-5} for Unit 2 of Temelín NPP for 2012 as compared with average value of calculated CDF from 2012 (1.39 x 10^{-5}) [12].

Implementation of PSA is an essential part of the operation of nuclear power plants. The results of PSA show that risks in nuclear facilities have been gradually reduced and they are below the reference level. This fact is one of the reasons why these facilities are approved for operation.

3.3 Major Disruption Of Drinking Water Supply

The following events can be determined as sources of disruption of drinking water supply:

- natural disasters (extreme long-term droughts, natural floods, flash floods);
- hydro-logical changes caused by human intervention;
- special floods;
- terrorism;
- human error;
- technical and technological accidents of a facility;
- lowered water level and yield of the resource;
- long-term interruption of electricity supply.

These sources of threat may affect different assets of the water management system in different locations unevenly. Between 2006 and 2010, the Waterrisk project (identification, quantification and risk management of public drinking water supply systems) was implemented. This project proposed a methodology for the identification, quantification and risk management of drinking water supply [13]. Also, it identified risks mainly on the basis of use of the FMEA method, Failure mode, effects and criticality analysis (FMECA) as well as Hazard Analysis and Critical Control Points (HACCP). The results in the area of hazards registries created for individual elements of the water management system are still usable and applicable.

A crisis situation would be announced, in the event of disruption of drinking water supply. After its declaration, emergency water supply would be activated and used. Also, for sources of the emergency water supply, risks were identified within a project called The Methodology of the Assessing the Emergency Water Supply on the Basis of Risk Analysis [14]. The author of this paper participated in the project. The brainstorming, FTA as well as What if methods were used for the risk analysis.

At present, it is only up to the water system operator to what extent the developed methods for risk analysis and risk assessment will be used for the infrastructure.

3.4 Leakage Of Dangerous Chemicals From A Stationary Facility

The area of major accident prevention has been based on the risk assessment since the outset. Depending on the risk degree, the objects are divided into group A, group B or unclassified. Also, classification of an object is determined by the extent of the processed safety and emergency documentation. The problem of many authors of safety documentation in the Czech Republic is that they perceive the identification of hazard sources of a major accident only as a legal obligation [15].

Until 2015, when the new major accident prevention law came into force (link), IAEA-TECDOC-727 was the most commonly used method of risk analysis. This method is not very suitable due to its properties and it is not on the list of recommended methods [16].

Currently, Fire and Explosion Index, Chemical Exposure Index and Guidelines for Quantitative Risk Assessment "Purple Book" CPR 18E are the most frequently used methods for facility identification. The results acquired through the Fire and Explosion Index and Chemical Exposure methods are not comparable with each other as they evaluate individual facilities from different perspectives. The selection method based on CPR 18E was primarily developed to identify major accident risk sources in an industrial facility. Despite the constant efforts to promote the use of this method in practice, there are many opponents who assail the results as well as the procedure of this method due to its relative complexity [15]. The method allows to determine how to choose the major accident risk sources on the basis of the same parameters and conditions.

The efficiency of the CPR 18E method is expressed in Table 6 using the number of identified major accident risk sources for different types of industrial facilities. Table 6 was created on the basis of application experience with the CPR 18E selection method. According to the number of independent units, the assessed facilities were divided into small, medium and large and subsequently the number of identified major accident risk sources in individual facilities was evaluated.

Table 6 The number of identified major accident risk sources for industrial facilities of different size [17]

Facility type	**The number of units (based on CPR 18E)**	**The number of identified major accident risk sources**
Small facility	up to 50 units	ca. 2 % of units
Medium facility	50 – 100 units	ca. 2 – 5 % of units
Big facility	more than 100 units	ca. 5 – 10 % of units

Additionally, within the prevention of major accidents, the Hazard and Operability Study (HAZOP) method is used for the identification of emergency situations, the FTA or ETA method is applied to assess the occurrence frequency of an extraordinary event. Hierarchical Task Analysis (HTA) and the Human HAZOP method are conducted for assessing human factor reliability. The methodological guideline [18] recommends the use of the ENVITech03 method to determine the environmental vulnerability and the H&V index method to determine the impact of accidents involving a hazardous substance on the environment.

A new type of risk analysis that is being used is Bevi Risk Assessments [19]. It is a modified selection method which brings a new approach to the selection of major accident risk sources.

Between 2000 and 2006, a criterion of acceptance of the group risk of a major accident was implemented in a decree. Following the cancellation of the regulation without its replacement, it was not possible to meet the requirement of the Seveso directive in the field of risk acceptance assessment. The Decree no. 227/2015 Sb. on the Requirements of Safety Documentation and the Scope of Information Provided by the Author of the Assessment [20] reintroduces the risk acceptance of major accidents based on the group risk criterion. In the risk analysis phase, this formula [3] is used to determine the group risk rate of identified scenarios:

$$Risk = F_h \times N \qquad [3]$$

R group risk rate of a major accident scenario (the number of people killed per year)

F_h annual frequency of the major accident scenario

N estimate of the number of people killed

When assessing the major accident risk acceptance, the group risk of a major accident scenario, for the vicinity of the assessed facility, is considered acceptable if $F_h < F_P$. is valid. This formula [4] is valid for F_P :

$$F_P = \frac{1\times10^{-3}}{N^2} \qquad [4]$$

F_P annual frequency of the major accident scenario

N estimate of the number of people killed

Interestingly, the new acceptance criterion for new facilities is ten times more lenient than the criterion from 2000.

3.5 Disruption Of Functionality Of Major Electronic Communication Systems

The Act no. 127/2005 Sb. on Electronic Communications and on Amendments to Certain Related Acts (Electronic Communications Act) sets requirements for security and integrity of public communications networks and electronic communication services under both normal and emergency situations. The operators of communications networks and services of electronic communication services must ensure such a level of security that corresponds to the degree of existing risk to prevent or minimize the impact of events on users and on interconnected networks. The problem lies in the fact that neither the level of existing risk nor risk assessment procedure is defined in this law [21].

In cases where the security and integrity of the communications network is compromised, in particular due to major operational accidents or natural disasters, the operator may suspend provision of the service or deny access to the service for the time necessary [21].

Disruption of the security and integrity of public networks and services may be caused by the following sources of danger:

- direct damage to operating facilities (operational accidents, technical failures, maintenance negligence, unskilled intervention, natural disaster, terrorism, mechanical damage);
- outage due to a sharp increase in network traffic and subsequent overload or due to an outage of another electronic communications network;
- dysfunctional behavior or cybernetic attack on control systems of the electronic communications network;
- disruption of power supply including disruption of power supply from a backup source;
- excessive restriction of the operators of facilities and equipment (epidemic, natural disaster, social reasons, emergence or danger of an armed conflict);
- intentional or unintentional electromagnetic interference [22].

3.6 Major Disruption Of Food Supply

Occurrence of this crisis situation will most probably occur as a secondary effect of another event (e.g. floods, long-term droughts, lack of water for food production, epiphytotics, epizootic, epidemic, disruption of traffic infrastructure, nuclear accident, terrorism). The crisis situation is characterized by a significant reduction in the production of safe food and deterioration in the quality of food thus affecting large numbers of inhabitants. Regardless of whether it is a standard or crisis situation, it is essential to ensure food quality and safety at any time. It is based on the application of the HACCP risk analysis method.

3.7 Major Disruption Of Crude Oil And Petroleum Products Supply

The Czech Republic is dependent on supplies of oil and petroleum products from abroad. These sources of danger can be identified:

- efforts of oil exporting and transit countries to make use of their dominant position to pursue their own political, economic and security goals;
- political, economic and security instability in oil exporting and transit countries;
- industrial and traffic accidents on the infrastructure;
- intentional disruption of the transport and distribution system as well as warehouses or production;
- organizational shortcoming in the sector;
- natural disasters [23].

Once the risk is activated, it will be a risk whose effects will last for several months or years. From the point of view of the transport infrastructure (pipelines), Pipeline Integrity Management (PIM) is used. Based on the risk analysis, PIM assesses the mechanisms for identifying priority, both inspectional and rehabilitative, events. With its risk analysis, new data processing methods and advanced visualization of results and relationships between them in cooperation with improved methods of the existing pipeline management, the PIM system significantly improves the degree of certainty that the pipeline will meet all the operational, safety as well as integrity requirements for the entire facility [24]. The use of other specific methods of risk analysis for disruption of supply of oil and petroleum products is not known to the author of the paper. However, it does not mean that they are not applied by the operators.

3.8 Special Flood

In the Czech Republic, these sources of special flood risk are identified:

- earthquake;
- long-term precipitation accompanied by torrential rains;
- landslides;
- terrorism;
- failure of dam construction and drainage of hydraulic structures.

All hydraulic structures are monitored and their technical condition is assessed with respect to safety, operational reliability, possible causes and malfunctions. These obligations arise from the Water Act [25] and the Decree no. 471/2001 Sb. on the Technical and Safety Supervision of Waterworks as subsequently amended [26]. This activity prevents failures and damage to waterworks including their surroundings and thus prevents the occurrence of special floods.

For water management structures falling into categories I – III, plans for the protection of the territory below the water body against special floods are prepared. These plans contain an assessment of the risk of special floods and maps with designated areas endangered by special floods. The maps are available to flood and crisis authorities [27].

In the Czech Republic, studies have been addresses with respect to the occurrence probability of a water body accident. Under the current system of technical and safety supervision, the likelihood of this type of flood for water management structures in categories I – III is less than 0.001, which is less than the scenario for floods with low probability of occurrence - Q_{500} (probability 0.002) [27].

3.9 Major Disruption Of Gas Supply

As with the oil and petroleum products supply, we are dependent on gas supply. These sources of danger can be identified.

- natural disasters (especially floods, extreme wind, landslides, extreme temperatures);
- anthropogenic accidents;
- terrorism;
- political, economic and security instability in gas exporting or transit countries.

The operator of the gas distribution system in the Czech Republic also uses the PIM system. Next, to identify risk sources, a diagnostic system, which makes it possible to predict accidents and adapt maintenance and repairs to the actual technical condition of the crucial technological facilities, is used [28]. Based on the performance measurements, it also predicts aberrations.

The use of other specific methods of risk analysis for disruption of gas supply is not known to the author of the paper. However, it does not mean that they are not applied by the operators.

3.10 Security Breach Of Critical Information Infrastructure

The risk of security breach of critical information infrastructure has not been subjected to the risk scooping and it has been immediately included among the unacceptable risks. Owners and operators of the critical information infrastructure are obliged to conduct risk management according to the Decree no. 82/2018 Sb. on Security Measures, Cyber Security Incidents, Reactive Measures and Establishing the Requirements for Filing in the Field of Cyber Security and Data Disposal (Decree on Cyber Security) [29]. The Decree on Cyber Security introduces a procedure for the qualitative (verbal) risk assessment of security breach of the critical information infrastructure. The formula [5] of the risk calculation is stated in the decree (link):

$Risk = impact \times threat \times vulnerabiltiy$ [5]

The authors of the decree were probably not risk management experts because the formula [3] is contrary to the general principles of risk assessment. Both vulnerability and impact are characteristics of an asset. Vulnerability refers to the asset's weakness, i.e. how a threat may affect the asset and impact speaks about the asset's extent of damage by the threat. In Formula [4], there is duplication in terms of the amount of damage to the asset. The decree verbally describes individual levels of risk but it does not indicate the combination of variables (impact, threat, vulnerability) in relation to the level of risk. Here is a major problem for entities which are required to follow the procedure.

4. CONCLUSION

There is a wide range of qualitative, semi-quantitative and quantitative methods for risk identification and analysis. Each of these methods has its own features affecting their usability, advantages and disadvantages. The choice of a specific method, or a combination of methods, is influenced by a number of factors among which the goal and type of analysis, the scope and availability of input data necessary for the analysis, the characteristics of the analyzed process, the particular assessment team and its experience as well as the cost of the analysis can be considered relevant.

Based on the conducted analysis of the application of risk analysis methods and procedures, it can be said that the use of risk management in the area of major accidents prevention and accidents of nuclear facilities is more widespread. These areas also represent the most hazardous activities in which the most accidents occurred in the past.

The current society, aware of its negative impact on the population, the environment and property should proactively approach the issue of risk management. Risk management should not be viewed as a one-time process but recurrent. Its primary objective is to minimize risks in accordance with the ALARA (As Low as Reasonably Achievable) principle. The risk management implementation related to hazardous activities is a complex multidisciplinary field which is necessary and indispensable part of crisis management of every country. In the case of risk management for hazardous activities, it should be an essential thing to implement the precautionary principle into all human activities. Only the implementation of the precautionary principle will reduce the manifestation of hazardous activities in the long term including negative cumulative and synergistic effects.

From the above presented examples of the application of risk management to hazardous activities in the Czech Republic, it is apparent that the legislative pressure to ensure safe and reliable operation of the given facilities is increasing. Therefore risk management is an essential tool for safety management. Its application is turning from a voluntary base to the mandatory legal level for entities whose activities are the source of hazardous activities. Despite the requirement to introduce risk management, the problem of not setting/defining the reference levels of risk acceptance remains. Another area, which should be emphasized, is the communication with stakeholders about risks.

Achieving safety and reliability of operation is only possible with risk management. Only the comprehensive integrated risk assessment and implementation of its consequences into all hazardous human activities will contribute to building resilience to disasters, fulfilling the prevention principle, supporting the sustainable development as well as securing safe environment. It follows that it is necessary to anchor risk management into all legal activities regulating hazardous human activities. Thus, risk management will become the basis of a system of management and control of a constantly developing modern society and the state will take responsibility for the safety coordination.

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Alena Oulehlová University of Defence, Brno, Czech Republic

alena.oulehlova@unob.cz

Alena Oulehlova Védelmi Egyetem, Brno, Csehország

orcid: 0000-0003-1685-5137