

The Analysis of the Risks of the Firedamp Leakage at the Ostrava-Karvina Mine District

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The article deals with the method of the safety risks analysis related to the methane leakage from the underground. The method uses the simplicity of the index method and the demands and the accuracy of the French MOSAR method as well. The MOSAR method is a system and systematic complex direction to work out the risk analysis. The analysis of the possible risks falls into fundamental ideas of the method namely the systematic sequence. The method sense is calculated the possible transfers of some danger. The index methods take advantage of the objective evaluation of the real danger related to the methane leakage from the underground.

The main objective of the method is a reduction of the probability of the contingency beginning related to the methane leakage from underground and of the reduction of the impact of the contingency; it means the risk management.

Key words: methane, risk analysis, MOSAR, index method, Ostrava-Karvina mining district

Introduction

The coalification creates the methane and this can be released with the consequent mining. This gas is ventilated properly and its concentration is monitored carefully. The mining loss was started at the Ostrava-Karvina mine district after 1990 [16]. The mining workings at the Ostrava-Karvina mine district has always been marked like mine workings with the massive coal gas capacity [7, 8] and these were classified as the mine workings with the dangerous methane occurrence. The atmosphere in the non-affected underground surrounding is oxygen free, explosive-proof and fire-resistant. This atmosphere becomes dangerous first of all if it is mixed with the air. The spaces, where this potentially dangerous atmosphere occurs, are connected with a surface of mine workings [16]. Each of these mine workings connected with gassy spaces might be dangerous for a population and its property in a way [14].

System under consideration

The word system is adopted from Greece and means an assemblage or combination of things or parts forming a complex or unitary whole [16]. It is characterized as a set of components with specific attributes and functions in the MOSAR method. The system is described with the contexture, the internal and external structures [2,3,5]. Systems are natural, anthropogenic or mixed. Components of the systems can be material, immaterial or combined.

Basic information about the risk analysis

Each of the human activities has various kinds and quantities of the risk and only the knowledge of these risks provides their possible management, reduction or elimination.

Index methods

A common attribute of this rapid ranking method group is using indexes for the evaluation of dangerous characteristics of the given system under consideration [4,10]. The safety is classified according to indexes into dangerousness categories. The method principle is the point evaluation of partial operations of the system under consideration on the basis of fixed calculations. One or more analysts should do these studies, the time demands are depending on the size and the complexity of the operation or the system under consideration [3].

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MOSAR method

The MOSAR method (Méthode Organisée et Systémique d'Analyse des Risques) – the organized and system risk analysis method is a French method [2-3]. It is a complex method systematically studying initial events of a potential accident and their possible consequences. The aim of the method is to consider possible transfers of danger [2-3].

The method includes following general steps: risk identification, risk evaluation, aim proposition and definition of the means of protection and of the risk management. Various partial methods and tools are used for the individual steps of the MOSAR method. Selected methods are mentioned somewhere else (e.g. [1,4-6,9,11,12]).

The MOSAR method is set up from two parts. The module A assesses the risks following from the external impacts to the system so-called the macroscopic view and the module B assesses the risks following from the system dysfunction so-called microscopic view.

The method sequence

The designed method can be used for analysis and evaluation of the risks of the systems above mentioned. The functional divide of the system can be created in order to help individual subsystems; it means subsystems are divided according to processes what are in progress.

The designed method uses the steps of the index method, and it serves for the evaluation of the given dangerous attributes of the system. The French method MOSAR was chosen for the complex determination of indexes.

The Fig. 1 shows the method sequence. The MOSAR method is represent by yellow colour and green colour is for steps of the index method.

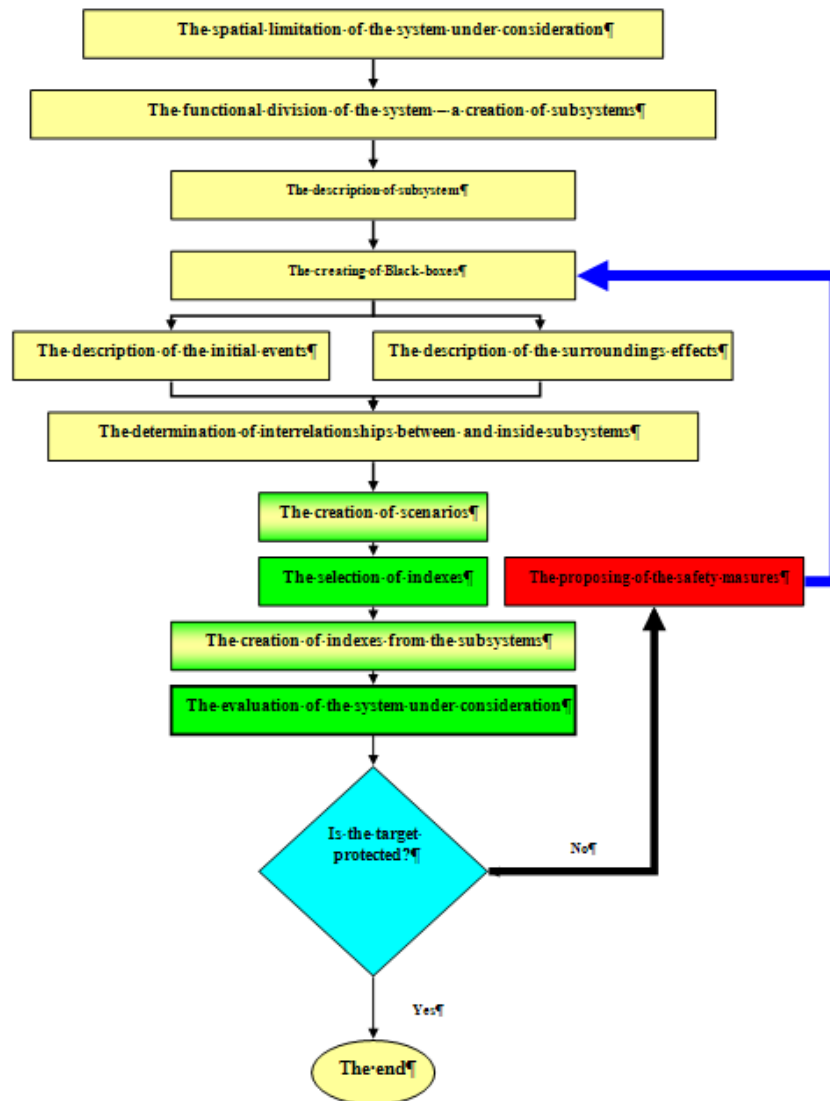


Fig. 1. The method sequences.

Safety risks evaluation method related to the gas leakage from the underground at the Ostrava-Karvina mine district

The designed system risk analysis (combined from the index method and the MOSAR analysis) is the methodical, step-by-step realized and objective evaluation of the imminent dangerous related to the methane leakage from the underground.

The index method evaluates the system occurring in the area bounded by a black coal deposit from below where the mining started and the boundary of the atmospheric layer limit from above. The lateral boundaries are given by boundaries of the Ostrava-Karvina mine district. The defined area enables application of the method for maximal number of places at the district.

The system under consideration is divided into homogeneous subsystems for a good arrangement and the simplification of the work during the risk identification. The full system under consideration is delimited. Constituent subsystems creates the function division of system, it means that the subsystems are divided according to processes which are under way in these subsystems. For the safety risks analysis related to the methane leakage were used six subsystems marked SS1 to SS6 (Fig. 2). Thus the system under consideration is limited spatially and functionally and it is divided into six subsystems.

The subsystem	The name of subsystem
SS1	Geological massif containing methane and underground water
SS2	Underground spaces with the firedamp
SS3	Atmosphere on the Earth's surface (the methane leakage into the open)
SS4	Buildings on the Earth surface (the CH ₄ leakage indoors) and their activities
SS5	Human society and environment
SS6	Safety measures

Fig. 2. The subsystems classification.

Firstly these subsystems were characterized with initiatory events and effects in surroundings in detail and then their mutual relations were determined resulting in creation of Black-boxes.

These safety risks analyses consist of four indexes. Fig. 3 shows the composition of these indexes. Only four indexes were selected because the work with a lot of indexes is unpractical, not clear and too difficult for man to distinguish rationally.

The subsystem	The name of subsystem	The index
SS1	Geological massif containing methane and underground water	The hazard index
SS2	Underground spaces with the firedamp	
SS3	Atmosphere on the Earth's surface (the methane leakage into the open)	The immediate danger index
SS4	Buildings at the Earth's surface (the CH ₄ leakage indoors) and their activities	The vulnerability index
SS5	Human society and environment	
SS6	Safety measures	The index of the improve safety measures

Fig. 3. The schematic representation of indexes.

Hazard index

This index consists of two subsystems (SS1 - Geological massif containing methane and underground water; SS2 - Underground spaces with the firedamp), which are determined by the MOSAR method. Thus, the index is composed of the geologic massif with the sufficiency of the methane, of the water and also of all of underground spaces with the underground atmosphere. This index is permanent⁴, dominant and it is a risk source too. It means if this index was zero then no methane source exists. This situation can occur when this method will be applied at the places where geological massif does not contain methane.

⁴ a change can come only at the water repump outside the underground

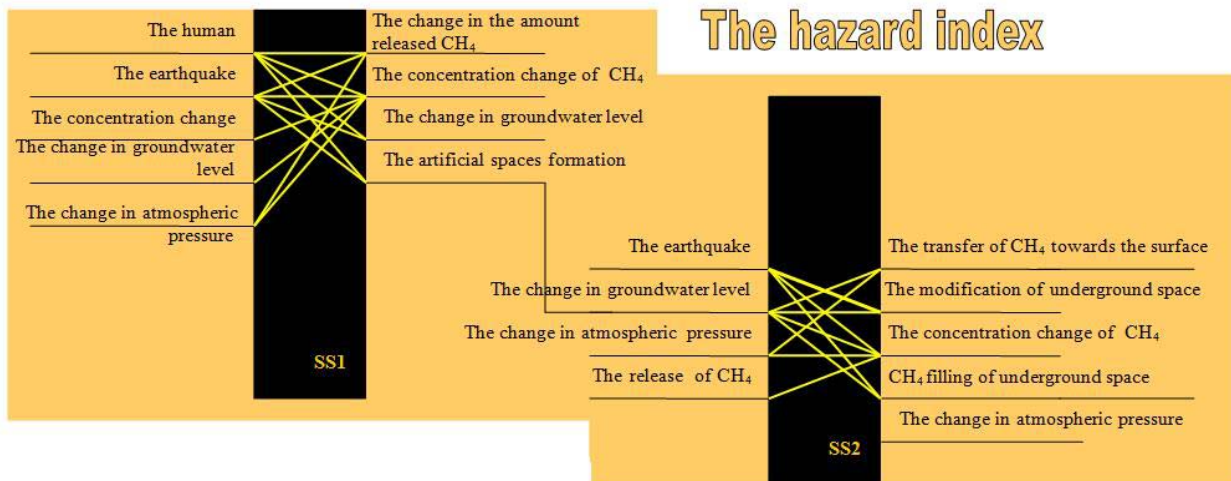


Fig. 4. The hazard index.

The immediate danger index

This index only consists of one subsystem (SS3 – the atmosphere on the Earth’s surface). The index evaluates the immediate danger; it means the immediate effect in the time. The initiator of the immediate danger can be for example the rapid change of the barometric pressure. The index is shown in the Fig. 5.

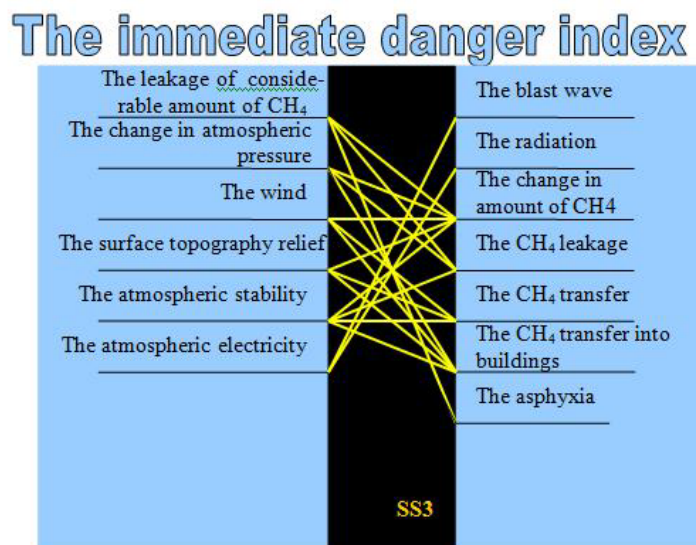


Fig. 5. The immediate Langer index.

The vulnerability index

The vulnerability index consists of two subsystems (SS4 - Buildings at the Earth’s surface and SS5 - Human society and environment). The index value depends on buildings characteristics (the CH₄ permeability, the ventilation, the windows type in the building...) and number of inhabitants in the buildings (the house, the nursery school...) or outside. The index value changes with the occurrence of the critical infrastructure elements.

This designed method focuses on the safety of the people, the property, the environment and the critical infrastructure elements so this vulnerability index is permanent.

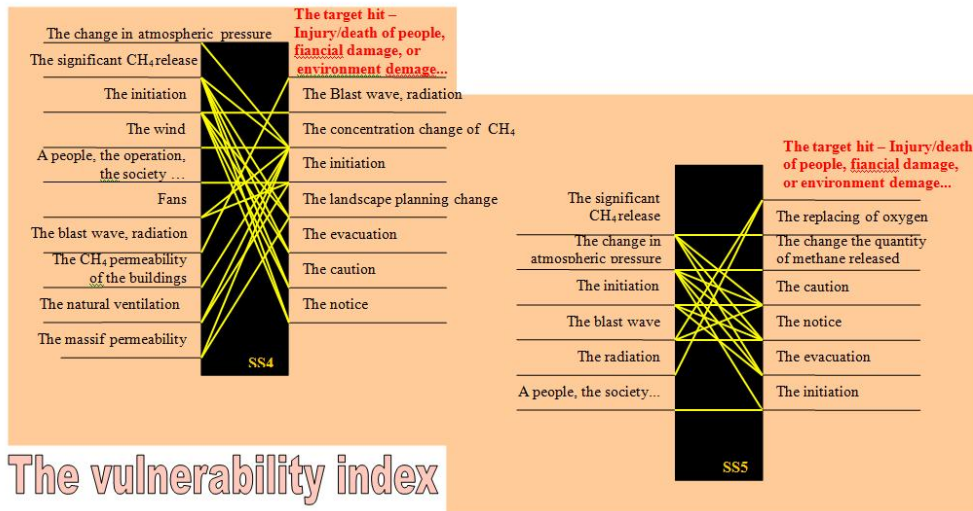


Fig. 6. The vulnerability index.

The index of the improve safety measures

This index (consists of the subsystem SS6 – The safety measures) is only one variable index. It can reduce the immediate danger or vulnerability. This index is very important, it can reduce the consequences of the accident, it means hazard by the CH₄ leakage. The index structure is shown at Fig. 7.

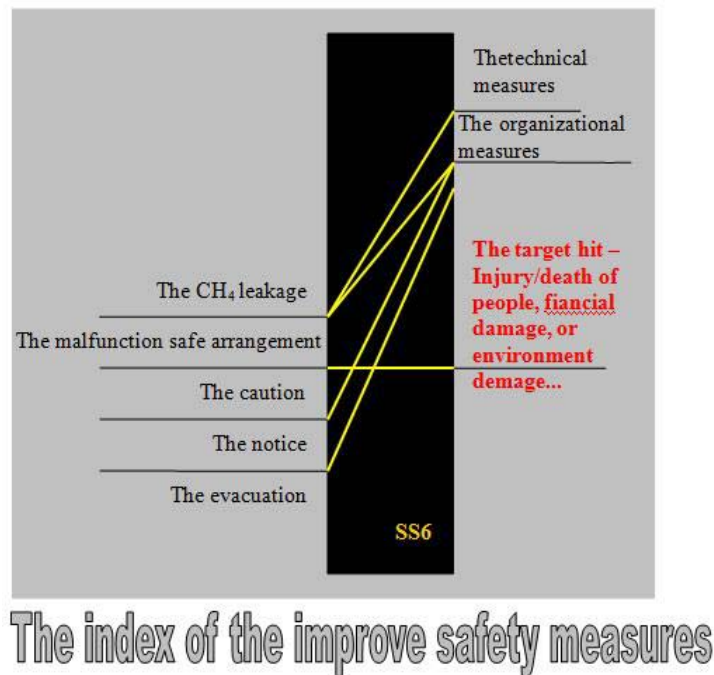


Fig. 7. The index of the improve safety measures.

All indexes and their interrelations are described in Figure 8.

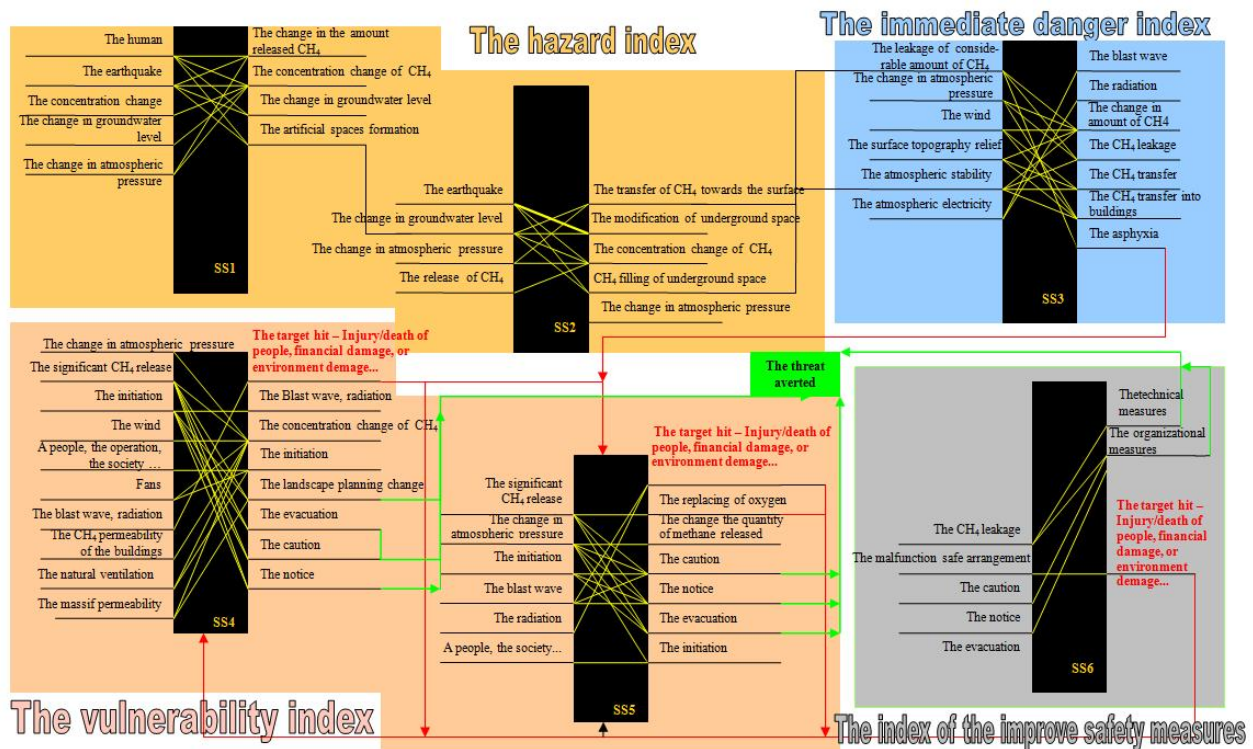


Fig. 8. All indexes and their interrelations.

Evaluation of data

The risk analysis method enables evaluation of danger factor related to the possible methane leakage from the underground for example by an easy choice of sites and types of building. All indexes consist of the string of the predetermined questions. The questions have preselected answers “yes” and/or “no”, or “I can’t tell”. These words are scored from 0 to 5. Zero means that the given initiatory event has no bearing on the methane leakage from the underground. On the contrary, the value 5 means that this event is of great importance to methane leakage. The total index is modelled by answering all questions and adding all of partial indexes. There is a diagram at the end of this method showing a danger measure for the given selected scenario. If the danger measure for the given scenario is in a red area of the diagram we recommend securing the place under consideration with safety measures. The green area shows the acceptable level of the danger measure. It means that the human health, the property and the critical infrastructure should not be damaged in all likelihood.

The program was created for evaluating this data. They are active index cards in MS Excel which evaluate danger areas and proposed safety measures.

The conclusion

We designed the method which uses the simplicity of index methods and the demands and the precision of the MOSAR method. A benefit of this method is its wide applicability. This method may serve as helping and decision-making tools for the crisis management, the population and the industry and also the mining management.

The final result of the analysis of the risks of the firedamp leakage will be used for the population awareness of the danger, for recommendation of possible changes in the landscape planning, building conversions, the monitoring and the warning and projecting of the safety measures.

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