RESULTS OF VERIFICATION OF RISK ASSESSMENT MODEL AND SOFTWARE PRODUCT IN THE SLOVAK REPUBLIC

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This article deals with verifying the Complex Model for Assessing the Risks of Industrial Processes and Software iMotýlik in a SEVESO company in the Slovak Republic. The results showed the possibility of its utilisation also for other companies especially the reduction of the administration load and increasing effectiveness in the area of processing the security and safety documentation.

I. STATE OF ART IN INDUSTRIAL ACCIDENT PREVENTION

There are several approaches to the risk management in the industrial environment. This process can be perceived as part of the security and safety analysis which is generally understood as studying the system, identifying the risk sources and dangerous situations in the whole system and their reduction and control. It is a formal title for understandable and systematic investigation of the engineering systems (especially the industrial processes) which can cause injuries of persons, depreciate the property or damage the environment if the stability is lost.

One of the areas utilising the security and safety engineering analyses is also the major industrial accident prevention which is managed by the directive SEVESO III in the EU and the main tool in the prevention framework in this area is the risk assessment. The basic aim is to prevent the rise of a major industrial accident and to assess the risks resulting from utilisation of hazardous substances in the industrial processes. Every member country transposes the directive SEVESO III in its legal environment and in the Slovak Republic the most important guideline is the law No 128/2015 Coll. about prevention of major industrial accidents. Currently there are several systematic approaches which the experts implement into practice, e.g.:

- Probability approach PRA, PSA, [1]
- Quantitative approach QRA, CPQRA (Stoffen, G, 2005), [2]
- Complex approach MOSAR, (Izvercian, K. et al., 2012), [3]
- Complex approach ARAMIS, (Volek, I, 2008), (Hourtolou, D. and Salvi O., 2002) [4,5]
- QRA and risk analysis software - Phast and Safeti. [6]

In the framework of the aforementioned approaches the individual steps make use of the principles of the following selected methods:

- FTA,
- ETA,
- Bow-tie diagram,
- HAZOP, HAZAN,
- What if analysis, Ishikaw diagram,
- FMEA,Check-list analysis,
- PHA. (Holla, K., 2013) [6]

These methods are described in the aforementioned sources but also in the selected technical standards not only on the international but also the national level. These approaches and methods are utilised by experts who implement them to the industrial processes during processing the security and safety documentation in the framework of the Major Industrial Accidents Prevention (MIAP).

SEVESO establishments in the Slovak Republic employ persons professionally qualified in the MIAP area or they ensure fulfilling the required tasks and duties by subcontracting to external authorized persons or companies. MIAP specialists and technicians have a license for providing such services and they are responsible for the compilation of the documentation required by the law. One of the decisive criteria for assessing the qualification level of the SEVESO establishment MIAP specialists is their knowledge and the ability to use the methods of major industrial accident risk analysis. The individual specialists were presented with 16 well-known methods for major industrial accidents (MIA) risk assessment (In project MOPORI). The specialists had also the possibility to state another method they knew and was not included in the list. The methods most often used by the SEVESO establishment specialists in the Slovak Republic were the ETA – Event Tree Analysis (39 establishments), FTA – Fault Tree Analysis (38 establishments) and safety audit (26 establishments). A detailed overview of the distribution of the MIA risk analysis methods used, based on the knowledge and experience of the MIAP specialists, is given in the figure 1. [7, 12]

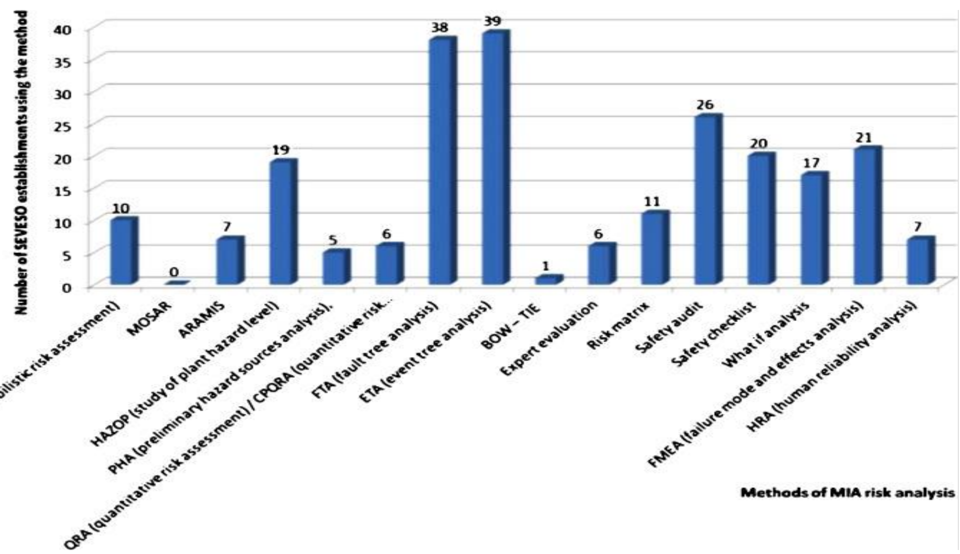

Figure 1 Overview of the methods for the risk assessment used in the Slovak Republic [7]

I. A. GOALS AND METHODS OF RESEARCH

Based on the analysis of the current state and the need of providing a new approach for assessing the risks for the SEVESO companies we solved a project for creating a comprehensive approach to the risk assessment in the SEVESO establishments.

The complex model was one of the main outputs of the research project APVV 0043-10 Complex Model for Assessing the Risks of the Industrial Processes (furthermore only MOPORI) which was solved from 2010 to 2014 at the Faculty of Security Engineering of the University of Žilina in Žilina.

The complex model was created on the basis of several steps and utilised several methods, procedures and tools. First of all it was necessary to define the main phases of the risks management regarding the complex model (assessing and managing risks) and subsequently to determine the individual steps. The solution was aimed at the phase of the risk assessment which was analysed and developed. The existing systematic procedures, methods and techniques for the risk assessment in the industrial environment in the Slovak Republic and globally were assessed for the necessary identification and analyses.

Based on several assessment criteria we chose some parts and calculation formulae of the European systematic approach ARAMIS, QRA method, Boolean algebra, fault trees, event trees and other procedures.

For stating the input and output parameters of the model we utilised the results of the tasks solved in the project framework:

- the analysis and synthesis of the conclusions resulting from the research of the SEVESO companies in the form of a research report „Statistical Survey of the SEVESO Establishments“ (furthermore only statistical survey),

- the working meetings (company Risk consult, s. r. o, Ministry of Environment of the Slovak Republic, VÚBP Praha and others).

During the working meetings we primarily solved the issues of creating the complex model and defining the input and output parameters. The value added of these workshops was – finding out the standpoints and opinions of the experts to the area being solved from various angles and this enabled the structure to develop continually. Based on these facts and procedures we created the "MOPORI". [8] Selected methods and calculation mechanisms were implemented in the created model. The methodology ARAMIS which consists of two key methods was the key approach on which the project team based its activities. The first one is MIMAH (Methodology for the Identification of Major Accident Hazards) - a methodology for identifying the risk sources of major accidents defining the highest risk potential of the equipment. The second methodology is called MIRAS (Methodology for the Identification of Reference Accident Scenarios) - a methodology for identifying the reference scenarios of the accidents. This method studies the influence of the security and safety measures on the scenarios identified on the basis of MIMAH. The model itself and its utilisation have been presented in several articles in magazines and at conferences. [8, 9, 10] This methodology was verified on two industrial processes at two SEVESO companies in the Slovak Republic. The basic aim of this article is to show the verification in one company with one hazardous substance.

I.B. RESULTS OF RESEARCH

The created Complex Model for Assessing the Risks of the industrial processes is determined first of all for the SEVESO establishments in the Slovak Republic and serves for assessing the risks connected with the law No 128/2015 Coll. about prevention of major industrial accidents as amended. The procedural development diagrams of the individual model phases were also created. The methods/parts of the systematic procedures were implemented to individual steps and subsequently the functional dependences between individual phases and steps of the model were defined. Based on the detected assumptions and the analysis of the currently used reference but also modern approaches/methods a model for the risk assessment of the industrial processes verified on the basis of practical implementations in two SEVESO establishments was designed and created. [9]

The procedure involves several elements of the currently used procedures for the risk assessment (ARAMIS, PRA, etc.) which create an algorithm which gradually enables to assess the risks in compliance with the legal regulations. The risk management and risk assessment as the basic phases and the steps they consist of are in compliance with the currently valid approaches, selected STN standards and legal guidelines. The advantage of the selected elements from the ARAMIS methodology is especially the possibility of their adaptation to the European environment of preventing the major industrial accidents and the harmony with the legal standards of the Slovak Republic especially in the final phase of defining the consequences, impacts and probability/frequency. The software iMotýlik contains the generic bow-tie diagrams which demonstrate the causes, effects and impacts of a critical event which can lead to a major industrial accident. [9]

Implementation in the XY Company

The company XY is a producer of additives to the fodders for animals. The selection of this SEVESO establishment for implementing the assessment procedures of the MOPORI project was realised on the basis of an agreement with the operator. As a matter of fact, only one selected hazardous substance utilised in the fermentation processes decided about its ranking to the B category. It is a 28 – 32 % solution of ammonia water which should not present any big threat for the employees and surroundings and its inhabitants in the area of warehousing, handling and implementing in the company because the potential risks are not connected with the ammonia water itself but with its leakages from the technology during an accident and subsequent evaporation of the gas ammonia to the surrounding. The technology of transportation in the company, tapping and warehousing the ammonia water as well as its implementation in the fermentation processes in production are simple, reliable and safe although they are not of the most modern character. Therefore we expected from the implementation of the risk assessment procedures prepared in the MOPORI project that the prepared procedures for implementing the risk assessment in the framework of the new SEVESO III directive in this company would significantly reduce the extent and depth of the assessment and risk analyses realised according to the law No 261/2002 Coll., as amended (the law about prevention of major industrial accidents).

In the framework of the first step we realised the preparation phase of the risk assessment and collected the necessary information for the realisation phase. The team was created by two MIAP specialists and the authorised representatives of the company management. The available report gives also a description of the analysed system and equipment in the preparation phase, description of the hazardous substances, stating the level of the risks´ seriousness and other information.

The first step of the realisation phase identifies the risk sources – they are the selection of the hazardous substances and equipment. Based on these inputs the critical events were determined, the probability of their development were described and defined. Thanks to the bow-tie diagrams created in the project framework the individual scenarios were analysed and subsequently we defined the impacts. The last phase was to assess the effectiveness of the barriers and subsequently designing new ones.

As an example we can show also the consequences of the dispersion of the representative accident scenario for the variant of the most probable and from the point of view of the impacts the worst class of stability 1F - see the following figure 2. This figure obviously shows that the buildings for inhabitants and services occur in the zone which can be threatened by the fumes.

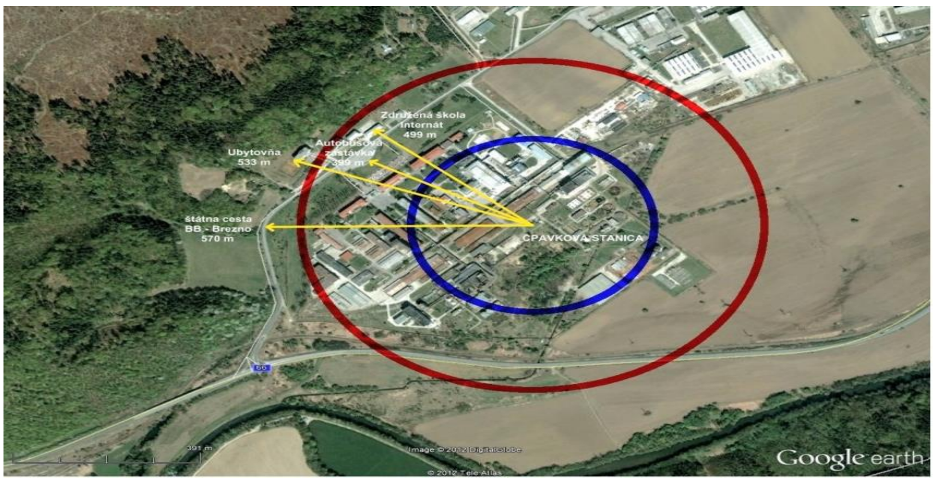

Figure 2 Stating the zone of direct threat and the zone that is endangered by the fumes of the leaked ammonia in the catastrophic accident scenarios [10]

Based on the created complex model and implementation of the preparatory and realisation phase by the working group dealing with the technological processes we verified all steps of the created complex model and the software iMotýlik.

I.C. Results and discussion

During the analysis and assessment of the effects of the individual accident scenarios the worst ones (with highest risk) showed to be the accident scenarios connected with the tanks of the ammonia water and handling when it is tapped.

In spite of the fact that the tanks are secured against leakages to the surroundings (collection and emergency tanks), a large leakage of this hazardous substance always represents an extraordinary risk of threat for not only lives and health of the operating staff in the company but also a direct threat of people, environment and property in the wider surroundings of the enterprise.

In spite of the fact the company organises regular trainings and exercises aimed at informing and preparing the employees for a potential occurrence of these emergency situations and the selected company employees have the means of personal protection, the leakages of the ammonia from the ammonia water cannot be fully eliminated even by the stable technical means and safety systems as well as mobile devices the emergency units work with. Due to the aforementioned reasons the individual risk of the danger for life and health of the operators at the Ammonia Station is high; however, it concerns only two employees who are present at the workplace during tapping the substance. As their individual risk is high they are provided with personal protection means and clothes and they are monitored if they fulfil the requirements of the safety and protection of health at work.

The limit of the individual risk for the employees is generally at the level of F=1.00 x 10^{-5} events. $year^{-1}$, i.e. as a threat for one inhabitant. However, this is impossible to fulfil in the company premises – especially in the close surrounding of the Ammonia Station and in the object itself where the corresponding isolines begin at the level of 1.0 x 10^{-3} events.$year^{-1}$ and in the distance of approximately 50 metres from the object the individual risk is in the area of 1.0 x 10^{-4} events.$year^{-1}$, i.e. in an area unacceptable for any individual risks. [10] The social risk is most frequently presented as the so called „F-N curve", however, from the legislative point of view the value of acceptability of this risk for the existing companies in Slovakia is at the level of l Fpr = 1.0 x 10^{-3} x N^{-2} events.$year^{-2}$, where N is the number of the endangered persons.

Original Calculation

The final value of the frequency of developing the major industrial accidents caused by the majority contributors was at the level of Fv = 1.41 x 10-3 event.year-1. Globally, these risk analyses consider the threatened persons to be only people outside the building and they can amount 10 % of the total number of endangered people, i.e. in the case of the company XY there were maximally 140 persons who entered the N value (number of endangered persons) for assessing the social acceptability of the risk. Then the value of the social risk of this company moved at the level:

Ffinal = 1.41 x 10^{-3} x 140^{-2} event.$year^{-1}$ = 2.76 x 10^{-5} events.$year^{-5}$
Fpr = 1.0 x 10^{-3} x N^{-2} events.year-1
Fpr = 1.96 x 10^{-5} events.$year^{-1}$ < Ffinal = 2.76 x 10^{-5} events.$year^{-1}$

and the company was in the area of the socially unacceptable risk. [10]

After Implementing the New Approach - Comparison

The utilisation of the complex model enabled eliminating or selecting mainly those accident scenarios which had a high probability of development (handling during activities at the tapping workplace), however, they resulted only in small leakages and had a negligible influence on threatening the surrounding and social risks (leakages up to 300 kg of the ammonia water or ammonia gas). The majority contribution for determining the probability of the development – occurrence of the hazardous industrial substances in the company XY - is that the enterprise already possesses the catastrophic accident scenarios which can occur after developing catastrophic fractures or collapses of the tanks at the Ammonia Station or after collapsing the tank in the company premises.

The total probability for occurrence of these accident scenarios (the critical events C10,C11,C12) and the corresponding „bow–ties" 43FT, 46FT, 47FT is at the level 1.165 x 10-4 events.year-1, which is a one step lower value than the total value for the corresponding „bow–ties" 21FT, 27FT connected with the critical events CE7 and CE8 on the tanks assessed – see the bow-tie diagrams in the document appendix, however, due to the character of these catastrophic leakages and the considered maximal number of the endangered persons (140) the final risk is as follows:

Ffinal = 1.165 x 10^{-4} x 140^{-2} events.$year^{-1}$ = 2.28 x 10^{-5} events.$year^{-1}$

but also this value is a socially unacceptable risk value in the conditions of the Slovak legislative environment, although the adopted and considered measures led to its reduction against the original risk assessment [10].

After using the generic quantification data for stating the probability and frequency of occurring the critical events it significantly reduced the administration load of the company in this area and the generic trees created in the framework of the MOPORI project can also significantly help look for the possibilities of further reducing the social risk of the enterprise.

II. CONCLUSIONS

The assessment of the final social risk of the XY company shows that the enterprise cannot be accepted from the point of view of the social risk and it will be inevitable to create corrective measures aimed at reducing this risk. It is not possible to change the construction and technical solution of the object Ammonia Station or its technology (horizontal one-coating tanks) - these changes would bring the required effect but they are financially demanding and hardly realisable in the conditions of the continuous operation.

Therefore the further measures should be aimed at increasing the reliability of the operators and the company emergency team and also at improving the effectiveness or completing the stable or semi-stable systems for creating water barriers after leakages of ammonia in the company or a stronger involvement of the called professional fire brigades into the repressive activities connected with the leakages of the ammonia water in the enterprise. However, a higher effectiveness and ability to take action of the emergency team and the fire brigades can be achieved only through improving the professional preparedness, exercising the accident scenarios and they also have to be equipped with the technical emergency means of individual protection. Based on the results of the verification we can say that the complex model with the software iMotýlik can be utilised also in other enterprises in the Slovak Republic. The main advantage is that the sequence of the steps does not allow omitting any important risk source and its subsequent analysis. Other advantages are also the pre-defined fault trees and event trees which are created in the excel form. They provide a possibility to complete the tree structures by the probability/frequency values and the effectiveness of the barriers on the right side. The table form of the individual combinations in selected steps helps visualise the given analysis better and it should objectify the used assessment procedures.

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