

**‘MIKLÓS ZRÍNYI’  
NATIONAL DEFENCE UNIVERSITY  
Doctoral Council**

**PHD THESIS**

**István Grafjódi**

**Title of PhD thesis:**

Research and development of technical and economic means and processes for preventing major industrial accidents and decreasing their consequences

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### **Determination of the scientific problem**

The occurrence of catastrophes of nature and civilization, the settlement of their consequences, and even the preventive and preparatory measures require certain amount of costs from the state and self-governmental organizations as well as from each participant of the economy, even from citizens. The consequences of catastrophes affect human life and health as well as may cause various damages in material goods (in built environment) and in natural environment.

In recent decades, the **protection against catastrophes**, the settlement of consequences of catastrophes and the introduction of preventive measures have become a **complex task system** interlacing the overall society, of which the cost of damages as well as the prevention and preparatory measures affect every participant of the national economy as well.

**Catastrophes of civilization** (especially industrial accidents) might be considered representative in respect of the costs of prevention, preparation for the settlement of consequences and accident settlement and recovery, as it appears in all the state and civil spheres of the society from the viewpoint of bearing the catastrophe protection costs and distribution of the damage liability.

**Catastrophe protection costs** (damages) arise in the relevant hazardous industrial plants, at the level of local and regional communities (mainly locally). In certain cases, the industrial accidents might have catastrophic, even over-the-border significance consequences as well. **The goods used for protection against serious accidents** appear in the budget of the relevant hazardous industrial plants, the authorities and other state organizations possessing catastrophe protection task as well as the residential and regional self-governments, **for the decrease (for cover) of which**, various **economic (financial) and technical methods (means and measures) exist** in the developed industrial countries as well as in our homeland.

The **operational costs** applied for prevention burden continuously the resources of profit-oriented economy participants; on long term, those expenditures exceed significantly the ones applied for the settlement of damage arising in the consequence of a possibly occurring accident.

This fact fundamentally determines the **safety philosophy of operators**. It is a characteristic feature of the developed countries and the domestic major companies that in recent years – especially at the major investors – the results of quantitative risk analyses are more and more taken into account. The operators may apply the **risk management results** for the decrease of possibly arising losses, creating favorable insurance fees, proving the reliability of supplier relations, reducing the risk based maintenance costs as well as the selection of risk reducing actions.

**The objective of the authorities** is to make understood and to make accepted the effectiveness of risk based approach, especially at the determination of risk reducing measures, where at the selection of possible alternatives, they obviously have to take into account also the economic interests of operators besides the "theory of mistaking on behalf of safety". The risk based quantitative risk analysis requirements determined in the domestic regulations support substantially the rationalization of operator costs in relation with safety.

In line with the above mentioned, the subject of the thesis is "**Research and development of technical and economic means and processes for preventing major industrial accidents and decreasing their consequences**".

### **Objectives of research**

1. To evaluate the effects of catastrophes (major industrial accident and extraordinary events) affecting the national economy and the corporate sector by in-depth analysis, systematization of international and domestic literature and its comparison with the practical experiences, and based on it to examine the practical applicability of the economic and financial means intended for prevention of major industrial accidents and for decreasing its harmful effects.
2. To evaluate – by critical overview method of Western-European and Overseas literature - the risk based system of means of preventing the damages (losses) occurred during major industrial accidents and extraordinary events in relation with the hazardous materials as well as the insurance practice closely related to that.

3. To evaluate and to systematize – by using the domestic and international literature and the practical experiences of hazardous industrial plants - the measures decreasing the harmful consequences and those of prior to accidents and breakdowns, based on risk management processes, applied at the hazardous industrial plants.
4. To analyze the application experiences of cost-profit analysis methods – that determine effects of the introduction of risk reduction measures on hazardous industrial plant competitiveness - in international operational practice, the strengths and shortages of the process, and based on it to work out the conditions of introducing them to Hungary.
5. To analyze and evaluate – based on foreign (United Kingdom and United States of America) operational and research experiences – the domestic application possibilities of a safe planning method, resulting from itself, primarily utilizable in the system of risk reduction measures.

#### **The research methods**

During my research work I take as a basic aspect the scientific grounding, the systematic approach, forming of conclusions based on analyses' and synthesizes, adaptation of foreign co-authorities' research experiences as necessary. My dissertation is made basically by using of objective facts and approaches - at the same time originating from the author's freedom – I apply my own statements, solution proposals and approaches.

A part of the literature used for my dissertation is from international and national literature, working papers, studies, professional articles and lectures, made available by the National Directorate General for Disaster Management. In my research work I processed a great number of foreign documentation (from international organizations, national authorities and non-governmental organizations) – also given as reference -, I made evaluation of relevance of the documentation and made adaptation to our domestic conditions.

During the research work, I have taken as priority the consultations with experts experienced in these issues and participation on scientific forums.

### **Brief summary of the research done**

Complying with my aim the **dissertation could be separated into four chapters**, where in the first (introduction) chapter I have studied the effects of catastrophes (industrial accidents) on the macro and micro economy and systematized these. In further chapters I have researched the adaptability of economy and technical tools – studied and applied in Hungary only in some cases - for prevention and loss-reduction of major industrial accidents, which are based on procedures industrial accidents management analyses and evaluations. First I have dealt with the practice of loss-prevention and insurance policy of the hazardous establishment, then I systematized the measures for reduction of risks of industrial accidents and finally I evaluated the adaptability of cost-benefit analysis method. In the last chapter of the dissertation – after definition of self-generating safety – I researched the possibilities of adaptation of the method domestically.

#### **CHAPTER I.**

##### Evaluation of industrial accidents' economic impacts

In order to comply with the aim of my research I analyzed first the costs arising from the prevention (awareness) of disasters, disaster management and loss preventions activities and systematized on national and corporate level. I researched exposed the costs in connection with the prevention of the environmental catastrophes (industrial accidents) and the environmental (industrial) safety aspects affecting the competitiveness of companies.

#### **CHAPTER II.**

##### Evaluation of loss-prevention practice and insurance policy of hazardous establishments

The aim of the second chapter was to evaluate the risk-based tool-kit for prevention of damages (losses) originating from major industrial accidents in

connection with hazardous substances and from emergency situations and/or the national and international insurance policy closely connected to this issue.

### CHAPTER III.

#### Reduction of risk of industrial accidents, investigation of application possibilities of cost-benefit analysis

In the third chapter I have demonstrated the advantages of industrial application of quantitative risk assessment (QRA), since the completed analysis's could be used by the operator for reduction of insurance covering the damages of technological breakdowns and industrial accidents, and/or it could be used for prevention of production-losses caused by emergency situations and accidents.

Based on international (primarily from UK) and domestic operational experiences I have analyzed the possibilities of applicability of QRA from economical point of view, by which I have systematized the risk-measures, furthermore I have individually demonstrated also via a test example the applicability of the cost-benefit analysis. A good example for up-to-date risk based loss-prevention procedure is the method „operation based on reliability”, what I have described at the end of the chapter and recommended for application.

### CHAPTER IV.

#### Evaluation of the method for self-generating safety design

In the last chapter I have dealt with the general philosophy of **hazard reduction and elimination**, and with the theory of more secure design coming from the self-generating safety.

The operator of hazardous establishments could apply this safety measure pack mostly at new establishments and at significant modification of already operating establishments. In this chapter, I have defined via examples the definition of the novelty design philosophy and the major elements.

## Summary of conclusions

### I. On the field of the evaluation of economic impacts of industrial accidents

1. The extensive examination of the prevention and preparation costs in some cases and the decreasing of the damages caused by disasters (industrial accidents) have a global meaning and **the solution of individual problems requiring international cooperation**. Technical knowledge and experiences obtained on the field of disaster management by the developed countries can be transmitted most efficiently by the help of the forums and programs of the international organizations.
2. The **extent of the damages** caused by disasters (industrial accidents) and the **expenditures** spent on prevention and preparations are depend on the followings: the nature and seriousness of the disaster, disaster endangering condition of the area, the value of the affected material goods, level of economic development of the country, development of the disaster management infrastructure and the disaster management awareness of the citizens.
3. The management of the events, which could cause environmental and industrial disasters, became a **strategic planning element** at the actors of the concerned industrial sectors, which could have an impact on the domestic and international competitiveness of the given company. As the result of the above-mentioned facts, the research of the economic impacts of the disasters has become one of the most significant independent scientific research task in nowadays.
4. Industrial accidents and extraordinary events entail significant costs to the industrial plants, which might **have impacts on the competitiveness** of the industrial plants in case of events with catastrophic consequences. **Prevention of major industrial accidents (environmental disasters) is closely connected with the usage of the tools of hazard identification, dangerousness and risk assessment, evaluation and mapping.**

5. As a result of the analysis of the cost factors of industrial accidents it can be laid down as a fact, that these factors are directly connected with the **loss prevention** of the extraordinary operating events leading to production outage.

The takeover of the general practice is **tightly connected to the activities and requirements of the insurance companies' related to industrial plants**. The risk assessment required by regulations, which is part of the safeguards against major industrial accidents in hazardous industrial plants does not have a purpose in itself, but besides the determination of insurance premiums and audits, it can be used for the introduction of risk measures and risk based maintenance, which can be considered as up-to-date methods.

## **II. On the field of evaluation of loss prevention practice and insurance policy of hazardous industrial establishments**

6. Referring to the facts mentioned in the section of evaluation of economic impacts of industrial accidents, it can be stated that the prevention of industrial accidents are in close connection with **loss prevention and the closely related insurance and reinsurance activities** introduced in the gas- and oil industry, as well as in the processing industry in the second half of the last century. Prevention requirements of the state and civil (insurance) organizations are connected to each other and point towards the high level assurance of personal and property security. It could be important to get mutually acquainted with the experience obtained on these two fields and exchange them.
7. Loss prevention generally means significant extra costs to processing industry, however on the basis of the analysis it can be stated that **the costs of companies running on good safety practice generally did not exceed the costs of the companies operating with minimal safety expenditures**. On enterprise level, the insurance seems to be a good deal in the long term. In order to take out an insurance policy the management of the company has to systematically review the factors, which could cause loss potentially.

8. **The hinge of the loss prevention is to take into consideration the costs of prevention.** After a detailed analysis, the management has to make decision about the fields on which measures should be taken in order to prevent losses.
9. **In order to decrease the financial risk of losses** companies running hazardous industrial establishments can take out an insurance policy with an insurance company. The assessment of the risks of the expectable losses is a significant question during the determination of the insurance money. The appraisers appointed by the insurance companies use special checklists and by the help of them the **hazard indexes** can be determined. Based on the loss frequency the loss profile of the hazardous establishment can be prepared, which make the determination of insurance premium possible.
10. As the result of the concentration of the chemical industry, which had happened during the past decades the introduction of the **Loss of Profit insurance** became necessary. This type of insurance has been separated from the other type of insurances. This type of insurance is not fully developed as the fire insurance. In The determination of the estimated losses in the Loss of Profit insurances is difficult, because the loss of production has to be converted into fixed costs, and the lost profit has to be included into the calculations in some form or other. The term of the insurance policy also has to be taken into consideration, as well as the involving of vendors and customers and, if there is any, in what extent.
11. **By the means of the determination of the insurance premium insurance companies could efficiently contribute to that, the operators of hazardous establishments would contribute to the reduction of industrial risks.** This condition confirms the requirement that **the administrative bodies (authorities) had to cooperate with the insurance companies on the field of industrial risk reduction.**

### **III. On the field of risk reduction of industrial accidents, investigation of application possibilities of cost-benefit analysis**

12. **The QRA is a useful tool** for the identification of those events, which are mostly contribute to the risk value (especially useful for major accident scenarios), as well as it can be used for the **determination of the benefits derived from the introduction of planned risk measures.**
13. Risk cannot be eliminated completely, for that very reason there is **proportionality between the risk and risk measures taken in order to reduce these risks. Risk of the occurrence of major industrial accidents can be reduced by the introduction of the following grouped measures: risk (hazard) elimination or reduction (inherent safety); reduction of consequences; reduction of frequency (probability of occurrence).**
14. The **QRA can be combined with the cost-benefit analysis (CBA)** in order to comply with the ALARP rule and determine that, whether the risk measures are worth for introduction or not.
15. **Operators of hazardous industrial establishments can obtain economic advantages by carry out the quantitative risk assessment,** which are show up as **the reduction of insurance premium,** serves as compensation for damages caused by technological faults and industrial accidents **and production loss prevention caused by extraordinary events and/or accidents.**
16. The „**operation based on reliability**” is a modern risk based method, which considerably contributes to the prevention (reduction) of losses caused by industrial accidents.

### **IV. On the field of evaluation of the method for self-generating safety design**

17. In our country scientific evaluation of the designing philosophy has not been done yet. So it is required to describe the concept of this philosophy and its elements. Self-generating safety design means **the implementation of such design philosophy, which main goal is to eliminate or reduce the hazards, instead of the management of these.**

18. Hazard identification in hazardous processes is characterized by subjectivism and uncertainty to some extent. Besides other risk assessment tools the self-generating safety design can provide **additional assistance in this process, if its strategic elements are applied systematically from designing to commissioning.**
19. **Self-generating safety measuring methods theoretically make possible the comparison of the hazard levels of different production processes,** and selection of those nodes, where the hazards can be **reduced** or in some cases they can be **eliminated entirely.**
20. Method of the self-generating safety design **can be applied widely,** such as in the applied industrial research and in process design. Principles of the self-generating safety design can be integrated to the inspection and regulating activities of public authorities supervising hazardous establishments. Objectivity can be increased by using the self-generating safety design principles in the legislation.

#### **New scientific results**

1. Performing deep analysis, systematization of the international and domestic professional literature and comparing it with practical experiences I *evaluated and systematised* **effects of catastrophes (major industrial accident and emergency events) affecting the national economy and company sector,** on the basis of which I *concrete determined* **practical application opportunities of economic and financial measures** serving for prevention of major industrial accidents and mitigation of their hazardous effects.
2. Applying method of critical review and analysis of Western-European and overseas professional literature I determined in detail risk **based measures of prevention of losses (damages)** occurring during major industrial accidents and **emergency events** involving dangerous substances, based on which **I proved in detail the connection of insurance practice used in hazardous industrial establishments with loss prevention system of measures.**

3. Using the international and domestic professional literature as well as practical experience gained in hazardous establishments I evaluated and systematised **prevention and mitigation measures based on risk analysis for limitation of consequences of industrial accidents** and operation troubles used for hazardous establishments, and on the basis of analysis and surveys I concrete developed **condition system for application of cost-benefit analysis method** determining affects of implementation of measures in context with competitiveness of hazardous chemical plant.
4. On the basis of examination and evaluation of foreign industrial experiences and research results as well as by presentation of practical examples I firstly determined **concept and elements of inherent safety** applicable in the system of measures of risk mitigation of industrial accidents; **elaborated opportunities for domestic implementation (adaptation) of the design method, and made concrete proposal for check list facilitating application of design method in hazardous establishment.**

#### **Recommendations of thesis**

- 1 Findings of my thesis may serve as basis for:
  - More deep cognition of scientific issues of survey of economic specificity of protection against catastrophes (major industrial accidents) and application of results in industry and in the practice of authority;
  - Practical application of quantitative cost-benefit analysis methods of industrial and authority foundational decision making in context with risk mitigation measures.
- 2 For preparation of methodological guidance of legal implementation of issues described in point 1
- 3 My thesis can be used as vademecum in the official education system of disaster management and Zrínyi Miklós National Defense University, as well as in education system of technical academics educational institutes dealing with chemical processes, industrial safety.

- 4 Surveys performed in my dissertation can serve as basis for determination of future research directions in the field of industrial safety and environmental safety.

I express my acknowledgement to my scientific theme leader, consultation partners and to all my colleagues, fellow workers and everybody who helped me with their work and suggestions in preparation of my dissertation.

### **List of Publications**

#### **In Hungarian language:**

1. István Grafjádi: Investigation of economical consequences of industrial accidents with special attention to the loss analysis and Insurance practice of hazardous establishment, Scientific Proceedings vol. IV. No. 1.
2. István Grafjádi: Inherent safety. Chapter of book – in the publication “Guidance to the application of regulation for protection against major industrial accidents” edited by the National Directorate General for Disaster Management (under publication)
3. István Grafjádi: Investigation of economic aspects of catastrophes with special attention to the effect of environmental disasters and industrial accidents on competitiveness of companies, Joint publication of Hadmérnök ZMNE BJKMK and KMDI (under publication)
4. István Grafjádi: Application of quantitative risk analysis for decreasing risk of industrial accidents, Joint publication of Hadmérnök ZMNE BJKMK and KMDI (under publication)

#### **In English language:**

5. I. Grafjádi: Application of Risk Analysis for Limitation of Consequences of Major Industrial Accidents in the Context of Seveso II. Directive AARMS ZMNE publication in English language (under publication)
6. I. Grafjádi: Assessment of Loss - Prevention and Insurance Policies related to the Consequences of Major Industrial Accidents. Proofread publication in English language. Faculty of Architecture of Szent Istvan University (under publication)

### Curriculum Vitae (Professional-Scientific)

**Name:** Grafjódi István

**Place and date of birth:** Miskolc, 25-th of March 1960

**Course of studies:**

- 2004-**        **Ph. D. student at individual course.** Zrínyi Miklós University of Defense, Military Technical Doctor School
- 2001**        **Master of economy in Bank management,** BKÁE University. Budapest
- 1993**        **Bachelor of Foreign Trade,** College for Foreign Trade
- 1990**        **Qualified engineer-economist,** Technological University of Heavy Industry
- 1984**        **Qualified metallurgical engineer,** Technological University of Heavy Industry

**Special courses:**

- 2001**        **Postgraduate Degree on Banking,** ITCB Consulting and Training Ltd. Budapest
- 1995**        **Special examination on exchange,** State Securities and Exchange Supervisory Authority
- 1994**        **Certificate Management Studies,** CMS Oxford OMEGAGLEN
- 1993**        **Bankruptcy and Crisis Manager,** State Property Agency

**Professional career:**

- 2006**        **Senior Manager,** ING Wholesale banking
- 2003 – 2006** **Senior Bank and Financial adviser,** CRONUS Group
- 1996 - 2003** **Miskolc Branch Manager (1996-1999), head of department,** CIB Central European International Bank Ltd.
- 1993 - 1995** **Chief Executive Officer – bankruptcy manager** Hungarian Bearing Works Share Holding Company, Debrecen
- 1987-1993** **Financial and commercial manager,** Hámor Joint-Stock Company Miskolc

**Research activities (publication data):**

- Newspaper articles: 5 pieces (2 English).; books (book chapters): 1 pieces.
- Lecturer of the Bankruptcy Management subject on the Szent István University Gödöllő

**Language knowledge**

- 1980**        **Russian** basic level examination “C”
- 1986**        **English** intermediate level “C”

Budapest, 25-th of May, 2007

**István Grafjódi**