Master of Science in Risk Management and Safety Engineering at Lund University, Sweden

Executive Summaries of the Master's thesis until August 2006

Johan Lundin & Robert Jönsson (editors)

Department of Fire Safety Engineering
Lund University, Sweden

Brandteknik
Lunds tekniska högskola
Lunds universitet

Report 7026, Lund 2006

Master of Science in Risk Management and Safety Engineering at Lund University, Sweden

Executive Summaries of Master's thesis until August 2006

Johan Lundin & Robert Jönsson (editors)

Lund 2006

Master of Science in Risk Management and Safety Engineering at Lund University, Sweden - Executive Summaries of Master's thesis until August 2006

Johan Lundin & Robert Jönsson (editors)

Report 7026
ISSN: 1402-3504
ISRN: LUTVDG/TVBB--7026--SE

Number of pages: 293

Layout: Nan Kjellberg

Keywords
Education; Master of Science; Risk management; Safety engineering; Master's thesis, University

Brandteknik
Lunds tekniska högskola
Lunds universitet
Box 118
221 00 Lund

brand@brand.lth.se
http://www.brand.lth.se

Telefon: 046 - 222 73 60
Telefax: 046 - 222 46 12

Department of Fire Safety Engineering
Lund University
P.O. Box 118
SE-221 00 Lund
Sweden

brand@brand.lth.se
http://www.brand.lth.se/english

Telephone: +46 46 222 73 60
Fax: +46 46 222 46 12

Abstract

To obtain a Master of Science in Risk Management and Safety Engineering at Lund University the students must write a master's thesis based on a final project. The efforts correspond to full-time studies for one semester, i.e. 30 ETCS credits or 20 Swedish credits. The students can choose to write the report in Swedish, i.e. their mother tongue, or in English. In addition to the thesis a student is also required to summarize the work in an executive summary written in English. This report includes the executive summaries written by students up to and including August 2006. A short description of the structure and contents of the Master's programme is presented in Appendix A.

Contents

How to handle county exceeding risks and vulnerabilities – A model applied on high torrents in Lake Mälaren and the catchment area

Hanna Langéen
Maria Lund

Abstract

The preparedness for flood disasters in Sweden is considered to be neglected compared to many other European countries. One reason is that risk and vulnerabilities are handled from administrative areas rather than natural boundaries. The problem around floods is county exceeding and therefore it needs to be looked at from a general perspective this to be able to reduce the communities vulnerability towards floods. The report introduces a model that describes how county exceeding risks and vulnerability could be handled.

Introduction

It seems to have become more common during the last years for some parts of Sweden to suffer a flood. Since floods and their consequences do not follow administrative boundaries, like municipal- and county lines, a general perspective to be able to handle the situation in a good way is often required. In the year 2000, cooperation between Stockholm, Uppsala, Södermanland, Örebro and Västmanland County was therefore started. The cooperation goes by the name *Mälardalens flood group* and intend to work for coordination and establishment of networks between participants who will be affected in case of flooding.

To be able to do the valley of Mälaren more robust towards floods, this report is considering how *Mälardalens flood group* should work to be able to handle county exceeding risks and vulnerabilities. Since floods are naturally occurring, the important question is how the preventative and preparatory work shall be shaped to work damage limiting and accident preventing. The aim with the report is to create a simple and structural model over a routine of county exceeding risks and vulnerabilities with regard to high torrents in Lake Mälaren and the catchment area.

Method

The report is based on literature studies, a case study and interviews. In the case study three cases have been studied – the flood situations in river Vänern-Göta year 2000/01 and southern Norrland year 2000 and the flood exercise that *Mälardalens flood group* carried out in the year of 2001. The interviews have been made in purpose to obtain information and knowledge about floods from competent persons.

Results

The report describes partly concepts of risk and vulnerability partly experience from previous floods. The chapter concerning risk and vulnerability considers concepts like risk, hazard, risk analysis, vulnerability and vulnerability analysis. The chapter about experience describes management work, information work, consequences and conclusions that affected participants and observers on the outside drew in connection with the flood situations and the flood exercise.

The model

From the concepts of risk and vulnerability and the experience a model is created which describes how to handle county exceeding risks and vulnerabilities. The model consists of six steps, figure 1.

Define objective, aim and system

To achieve an efficient risk and vulnerability management, it is important to define goals, purpose and a system, to create a common ground for future work. It is of great importance to define a common meaning of risk and vulnerability to avoid misconceptions.

To be able to get a wide picture of the extent of the system the spread in time and area must be define and some delimitations must be done. The systems extent in area constitutes by the geography area that will be handling, in this case Lake Mälaren and the catchment area. Extent in time involves defining which aspect of time that will be handled. We consider it to be the time from What is worth to be

protected is threatened until the situation is under control again. To delimit the system means to take a position if only the systems own ability to handle a strain should be considered, or if available resources even outside the system should be considered.

Define what is worth to protect
To define what is worth to protect means to set what is primary to protect and then what is secondary to protect.

We consider that the primary to protect is the individual and its needs. The secondary to protect consists of objects and functions in the community which is necessary to be able to satisfy the individual needs.

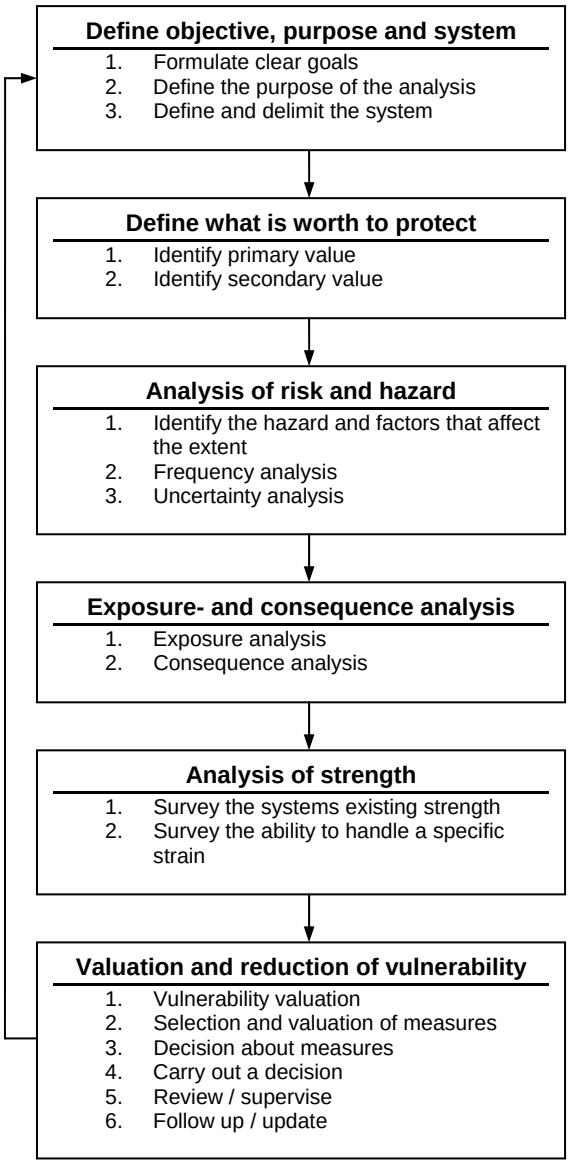


Figure 1. Model over how to handle risks and vulnerability

Analysis of risk and hazard
In this case constitutes the hazard of Lake Mälaren and the catchment area and the risk constitutes of a flood. Frequency analysis means to analyse the probability that the hazard shall create a risk. Even the uncertainty must be looked at.

Exposure- and consequence analysis
The exposure analysis intends to survey object and functions which is worth to protect and which can be exposed in connection with a flood.

The aim with the consequence analysis is to identify direct and indirect consequence which comes up in connection with that object and functions which are worth to protect will be exposed.

Analysis of strength
The analysis of sturdiness means to survey the systems existing strength. Even the systems ability to handle a specific strain, as a flood, shall be surveyed.

Valuation and reduction of vulnerability
To value the vulnerability means to decide whether the strength is acceptable or not. If the strength not is acceptable demands proposal of measures and a decision about which measure that should be taken in action. Finally the process should be reviewed and followed up.

Organizational structure
To make the model work for a county exceeding hazard, a thoroughly worked organizational structure is demanding. In the report it is suggested that *Mälardalens flood group* should be organized around stream coordinated groups with a common work committee. This is in purpose to be able to handle risks and vulnerabilities that come up in connection with a flood in a good way.

The work committee constitute the deciding bodies in the county exceeding questions which concerns with floods. The committee remains of representatives from respective coordinated group. We recommend that every coordinated group are divided in four under groups, one analysis-, one social-, one technical- and one ecological under group (figure 2).

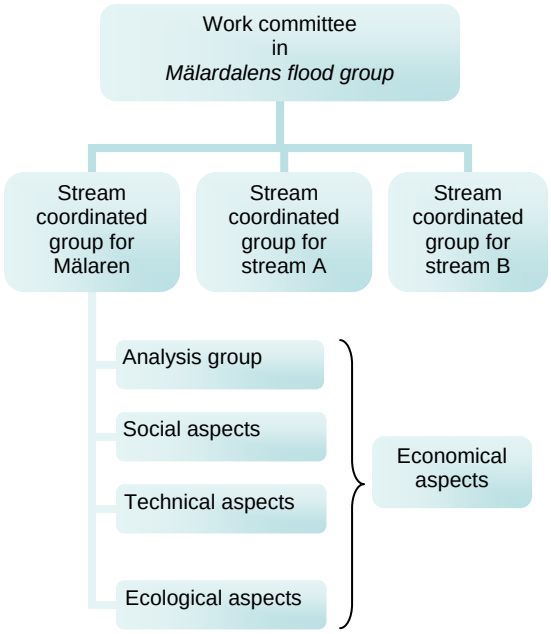


Figure 2. Proposal on organizational structure for Mälardalens flood group

The task of the analysis group is to analyse hazards and estimates the probability that a flood will occur. The aim with the other under groups is to get the consequences on the basis of the different aspects to be looked at equivalent. The economical aspects is not handle separate but is treated within respective under group.

Conclusions

In connection with the work of this report following conclusions been taken.

- A Water systems natural boundary should decide how risks and vulnerabilities in connection with high torrents should be handled.
- Since floods are naturally occurring the focus must be kept on the preventative and preparatory work. So that damage limiting and accident preventing strategies could be found.
- GIS should be used in greater extent this to be able to illustrate existing preparedness to which areas, objects and functions that are vulnerable.
- The knowledge around risk and vulnerability has to be improved to create an understanding of the problems connected with for example high torrents.
- The work to create a criterion for valuation of vulnerability must go on. Just like the work to create an economical valuation of measures and their vulnerability reducing effects.
- To make the management of risk and vulnerabilities to be a part in the everyday decision activity. The dialogue with the politicians must be improved.
- Floods do not follow administrative boundaries and therefore needs to be looked at from a general perspective.
- To be able to handle risks and vulnerabilities in a good way guidelines and good cooperation are required. This is extra important when the hazard is county exceeding.

Study of risks associated with the handling of fireworks – Focused on the control of authorities

David Forsander
Henrik Jönsson

Abstract

The purpose of this report is to study the risks for people that are caused by the handling of fireworks and then relate the risks to the control of Swedish authorities. The authority control must secure an acceptable level of risk at occupations that handles fireworks. Fundamental for this is that the regulation enables the control of authorities. Conclusions that have been drawn in this report can be used in order to change the Swedish regulations and the application of them. The types of handling that this report focuses on are storage, sales and events.

Introduction

Using fireworks is a tradition in Sweden, in conjunction with celebration of New Year, Easter and last day of April. Fireworks are also used in conjunction with concerts, displays and sport events. The usage of fireworks is associated with risks for people, property and the environment. The purpose of this report is to study the risks for people that are caused by the handling of fireworks and then relate the risks to the control of Swedish authorities. The type of handling that this report focuses on is storage, sales and events.

Fireworks are stored by suppliers in large warehouses, where weights in the order of 10-100 tonnes are stored, but it's allowed to store as much as 200 tonnes according to the Swedish regulation/1/. These warehouses are located in sparsely populated areas. Firework storages that are located in more densely populated areas are storages in connection to shops. In storages like that up to 100 kg can be stored/1/.

Sales of fireworks take place in superstores, malls, retail trades and other small shops. The sales are very concentrated to New Years Eve and Easter, which means that most shops store large quantities of fireworks temporarily during these occasions. Usually fireworks isn't part of the regular range of products that the shop is offering, therefore the handling might be insufficient and can cause large risks. Another issue is that New Year and Easter are public holidays when sales are high, which means that the stocks are full and this could cause high fire hazards. Many people are also likely to attend the shops. These two aspects combined work adversely with respect to the magnitude of the risk.

Several Fire services in Sweden are dissatisfied with the regulations that are applicable on the handling of fireworks. They think that the regulations today don't enable authorities to secure an acceptable level of risk. They also consider that the recommendations and guidance from the Swedish Rescue Services Agency (SRSA) are insufficient. The question whether their point of view can be verified through scientific studies is the main objective in this report.

The greatest hazards that are associated with the handling of fireworks are if mass-detonation takes place in a warehouse, if a fire occurs in a storage that is located adjacent to a shop, if a fire occurs on a sales counter or if fireworks ignite other combustibles in an indoor event. The serious consequences that scenarios, like those, can result in are for example proven by the accident in Enschede, 2000, and the fire at the nightclub The Station, 2003, where 22 people/2/ and 100 people/3/ died, respectively.

Method

In order to fulfil the purpose of this report empirical and theoretical information have been studied. Knowledge has been obtained from empirical information sources, such as interviews, observations, visits at occupations and questionnaires, both common and web-based. The empirical information has been used to survey the handling of fireworks and to gain knowledge of the application of the Swedish regulations. The theoretical knowledge has been obtained from a literature study where sources as books, reports, accident investigations, scientific articles and relevant regulations have been studied.

Authority control

Authorities can affect the level of risk, at an occupation, indirectly, by affecting factors that are called risk affecting factors (RAF). An RAF is a factor that has a direct affect on the level of risk at an occupation and that authorities can govern by regulations, recommendations and supervision. Risk affecting factors at occupations that handle fireworks can be of very varying character, for example concrete (e.g. passive fire protection), abstract (e.g. level of knowledge) or product related (e.g. firework type).

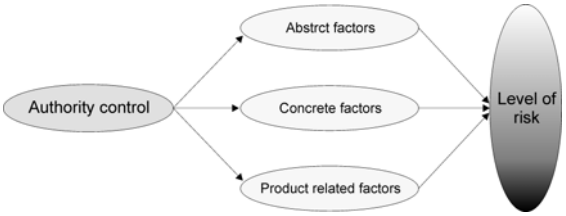


Figure 1. The connection between authority control and the level of risk.

A fundamental condition for authorities to be able to govern an occupation, with the purpose of achieving an acceptable level of risk, is that the regulation enables the authorities to practise their control. Thus, it is very important that the Swedish regulations enable the authorities to secure an acceptable level of risk. Another important aspect is that the Swedish regulations are complied with. The Swedish authorities can affect this by applying the regulations in a proper way and perform supervision.

Adapted risk management model

An adapted Risk Management model was developed in this project. The purpose for this was primarily to systemise the approach in this report. The basis for the model was a standard Risk Management model/4/, which was adapted in order to suit this project. The greatest difference between de adapted model and the standard model is that the adapted model not is focusing on risk but risk affecting factors.

The first step in the model was to identify the factors that affect the magnitude of the risk at an occupation. The second step was to perform a Preliminary Hazards Analysis, where each RPF was analysed. Those factors that were considered not to have an enough influence on the level of risk, to motivate a detailed analysis, were screened out. The third step was to perform a detailed estimation of the influence on the level of risk by the RAF, that were chosen in step 2. In step four the influence on the level of risk by the RAF was compared to the control of that factor by the Swedish authorities. The comparison led to an evaluation whether the control can secure an acceptable level of risk. In the last step changes was suggested for the control of those factors that weren't governed adequately.

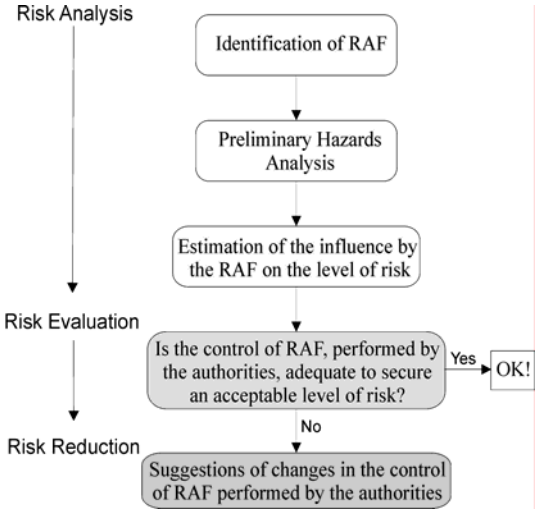


Figure 2. Adapted Risk Management model.

Conclusions

In Sweden today, the control of authorities, of occupations that handles fireworks, is insufficient in order to secure an acceptable level of risk at those occupations and in areas surrounding them. There are several causes for this, where the most important cause is that the Swedish regulation doesn't enable the authorities to secure an acceptable level of risk. Several proposals for changing and improving the Swedish regulation have been identified; the most important suggestions are as follows:

- Small storages should be required to be placed in fire-separated compartments, tentatively with EI-60.
- Those parts of the regulations that can stimulate an improved safety culture, tentatively requirement of risk assessment and systematic approach to fire protection (SBA), should be practised in more extent.

- A system for certifying pyrotechnicians should be implemented in the Swedish regulations.
- The certifying system should contain both practical and theoretical elements and should be arranged or scrutinized by the Swedish Rescue Services Agency (SRSA).
- It should be required, that the involved participants in a fireworks event cooperatively produce a safety plan.
- Sales or distribution of fireworks from containers, in proximity to shops, should be allowed and encouraged.

The control of Swedish authorities should in the future be more focused on abstract factors, such as safety culture, safety contemplation and level of knowledge. The Swedish act, lag om brandfarliga och explosiva varor/5/, regarding flammables and explosives is the primary act that is applied on the handling of fireworks, is a prescription based regulation. The provisions are mostly aimed at technical requirements, for example maximum amount of fireworks allowed, safety distances and fire protection requirements. The abstract factors are not sufficiently addressed in this act. The new act, lag om skydd mot olyckor/6/, regarding accident protection is a performance based regulation, which to great extent aims at the occupiers own safety contemplation. This act is an excellent and sometimes necessary tool for authorities to use when it comes to securing an acceptable level of risk. Today lag om skydd mot olyckor is applied to a heavily varying extent around the country, regarding the handling of fireworks. One reason for this might be that the boundary establishment between the two acts is diffuse. This might imply that lag om skydd mot olyckor often is neglected, since it doesn't explicitly address the handling of fireworks. In the future the central authorities (for example SRSA) must interact in order to elucidate the boundary establishment between different regulations and then hand out recommendations to the local authorities (Police, Fire service). The recommendations should contain information on when different decrees are applicable and when several decrees can be applied simultaneously.

Today, the Police are the authority that processes most matters that are related to the handling of fireworks, the Fire service only gives statements on matters submitted for consideration. The knowledge that the Police possess regarding fireworks and risks associated with them are not sufficient and this is augmented if "lag om skydd mot olyckor" in the future has to be used in greater extent. The responsibility of processing matters that concern the handling of fireworks should, thus, be transferred from the Police to the Municipal. This would practically mean that the Fire service gets the responsibility. The Fire service possesses far more knowledge, foremost regarding lag om skydd mot olyckor. Insufficient knowledge, regarding the handling of fireworks and the risks associated with this, is also a fact for the Fire service, competence development is therefore a critical factor in the future

Discussion

More research, about fires that involve fireworks, is needed in order to find out how such a fire behaves and which factors that have an influence on the behaviour. Interesting research could be to estimate heat release rate, smoke development, fire spread distance and so on.

More research is also needed in order to gain more knowledge about the phenomenon mass-detonation. Today the knowledge seems to be insufficient and since mass-detonation is a very hazardous event it's important to attain a high level of knowledge in this area.

References

1. *Sprängämnesinspektionens föreskrifter om hantering och import av explosiva varor med ändringar i SÄIFS 1997:5 och 1998:4* (1989), Sprängämnesinspektionen, SÄIFS 1989:8.
2. Corkery M., Parker P. E. (2003), *Life and Death*, The Providence Journal, December 12 2003, Providence, USA.
3. *Explosion i fyrverkerilager Enschede, Holland* (2000), Observatörsrapport, Internationella Avdelningen, Räddningsverket, ISBN 91-7253-098-7, Karlstad, Sverige.
4. *Risk analysis of technological systems* (1995), International Standard IEC 300-3-9, International Electrotechnical Commision, Genéve, Schweiz.
5. *Lag om brandfarliga och explosiva varor* (2003), Försvarsdepartementet, SFS 1988:868.
6. *Lag om skydd mot olyckor* (2003), Försvarsdepartementet, SFS 2003:778.

”Value-at-Risk”- analysis of the production chain – An applied method for evaluation of machine and supply chain risks

Marcus Johansson

Abstract

A method for evaluating the consequences of business interruption attributable to machine failure or loss of supplier has been developed. Simplicity and transparency are two factors that have been given significant weight in the development process to make the method applicable in practice in the, always resource scarce, industrial environment. The method is a semi-worst-case method and hence do not take any probability issues into account. On the other hand does the method take full account of the epistemic uncertainties that is present in all risk analysis work.

Background

During the last decades has the way from raw material to finished product grown increasingly complex[1] and often are products with great knowledge content delivered from suppliers all over the world. The problem with this is that the supply chain is getting increasingly vulnerable and it is often hard to find an alternative supplier if the regular supplier fails to deliver for example due to a major fire or bankruptcy. A well known example of this is the fire at Philips factory in Albuquerque[2], New Mexico, which caused Ericsson losses in the SEK five billion range[3]. In the same event another motivation factor can be found. Nokia depended on the same supplier, but only suffered minor losses and this was in large due to business continuity planning where routines how such an event should be handled could be found. An indicator of the kind of priority such an interruption was given was that Nokias CEO flew down to Albuquerque the day after the fire was known to secure future deliveries. This shows the great benefits from proactive risk management and serves as a motivator for the present study.

Risk Management of the production chain

Traditionally production risks have been handled through *ad hoc* activities; when an interruption have occurred the company settles a plan of how to handle it. As the market got increasingly complex and competitive the need for proactive risk management of production risks grew stronger. On the other hand has the increased competitiveness resulted in resource lean production and hence fewer resources available for risk management. This development has led to the development of the present tool. The tool developed in the present paper requires very little resources, but does still provide a valuable input to the decision making process.

The tool

The work process is divided into nine separate steps.

1. Walk-through of the plant
2. Planning and demand setting
3. Quantification of safety stock for finished products.
4. Analysis of machines
5. Analysis of raw materials
6. Economical factors
7. Calculations
8. Presentation

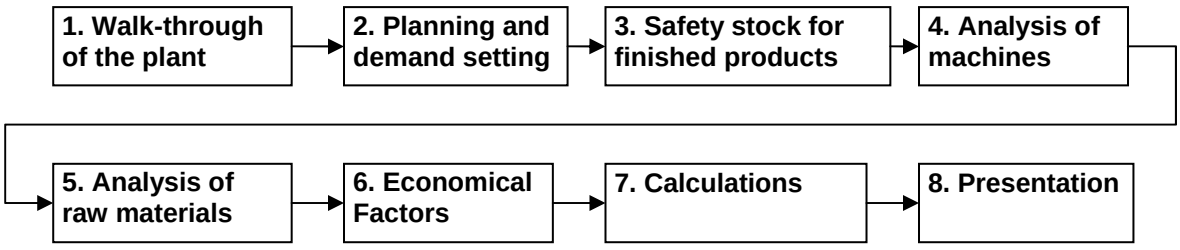


Figure 1. The work process.

The first two steps are rather intuitive and there is not much to be said about them. The first step "Walk-trough of the plant" is meant to orientate the analyst if the analyst has limited knowledge about the processes in the plant. The walk-through is rather coarse and is only meant to give a brief overview of the process and products. The second step "Planning and demand formulation" is important to achieve a product that corresponds to the needs of the decision maker. The third step is of great importance for the analysis since only damage made by inability to deliver to customer is considered and hence interruptions that last less time than the safety stock for finished products do not need to be considered. After the safety stock has been quantified (in time) the analysis moves on to analyze the first set of risk sources; risks attributable to loss of machines.

Machine risks

The analysis of machine risks can be divided into two steps; preliminary analysis and interruption quantification. The preliminary analysis is simple and is conducted during a walk-through of the plant together with experts from maintenance and from the department in question. For each machine two questions are answered:

- Can production be maintained without major impact on volume?
- Is time to repair or time to find an alternative producer less than the safety stock?

If the answer to both these questions is yes, the machine should be analyzed further otherwise no further analysis is needed.
After this preliminary analysis a subset of the machines that constitutes a potential hazard to the production process has been derived. These machines are more closely examined and the maximum repair times are quantified by experts from maintenance or other closely related fields. The maximum repair time can either be formulated by means of an interval or as a triangular distribution. The interruption time can then easily be calculated by subtracting the safety stock of the finished products. At this stage a set of interruption times has been derived and the analysis process moves on to analyze the raw materials..

Supplier risks

The analysis of raw materials is also divided into the same two steps as above; preliminary analysis and interruption quantification, but the processes are a bit different. A complicating factor is that many plants have a vast number of raw materials and hence can not each raw material be analyzed. This call for a different method from the one presented above. The present method is fully subjective and consists of people from the purchasing department naming a limited number of raw materials that they believe constitutes a great hazard. This step naturally induces a lot of subjectivity into the analysis process, but this seems to be inevitable since the number of raw materials is so high. When a suitable number of raw materials are identified the purchasing time for each raw material is quantified through discussion. The purchasing time can be formulated as an interval or a triangular distribution. The interruption time is the calculated by subtracting the safety stock for both finished products and for the raw material in question. When the interruption

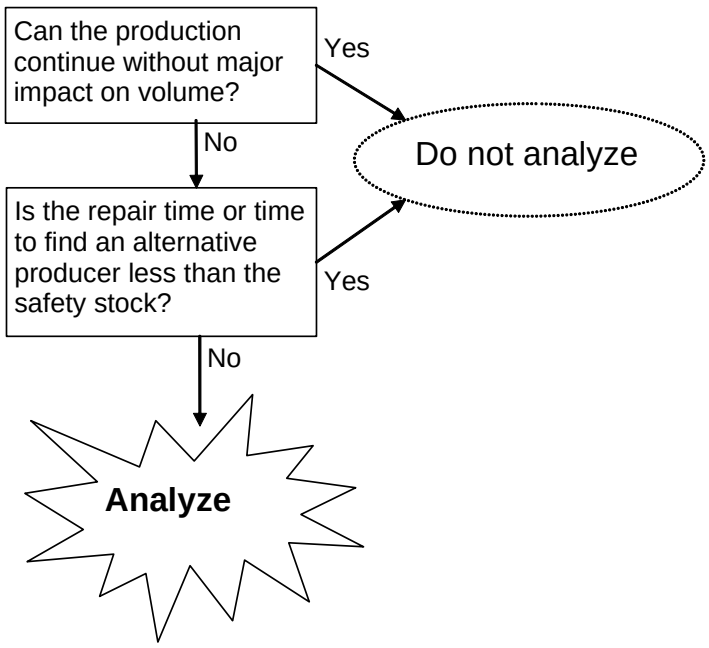


Figure 2. The preliminary-analysis methodology for machines

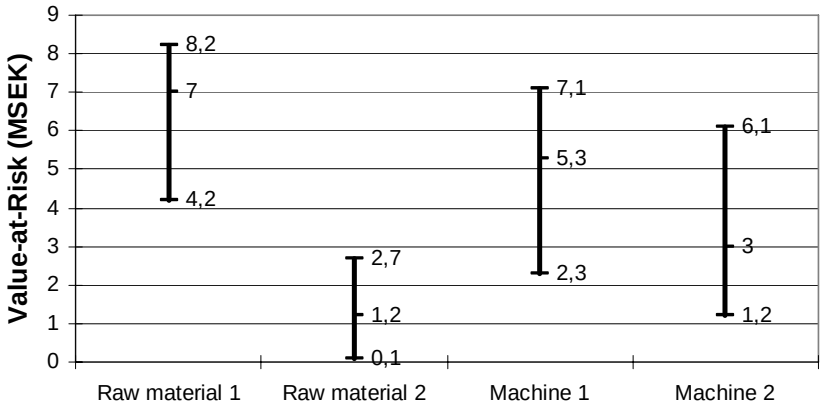


Figure 3. Value-at-Risk shown with 95%-confidence interval

times for both machines and raw materials are found the economic consequences of an interruption needs to be identified. First the insurance coverage needs to be found.

Insurance coverage

Insurance coverage is of great importance for transferring rare events such as this model handles and hence need much attention be put to the terms of the insurance. There are three major factors that are of interest to the present study. These are deductibles, coverage and the period of indemnity.

Insurable losses

The insurable losses are rather easily quantified. The loss simply consists of loss of contribution margin from the products not possible to be delivered. This should simply be described as dollars per time for each loss scenario.

Uninsurable losses

Much more work needs to be done in this field. The present paper is based on the sources of uninsurable losses as found in ÖCB(4) a few of which is listed below.

- Lost sales beyond the period of indemnity and interuption
- Lost post-sales
- Fines
- Extra marketing

Methods for quantifying these has been developed for the case study, but to few case studies has been conducted to generalize these findings to the industry in general. Therefore is the analysis, at this stage, advised to conduct own methods based on discussions with the marketing department. This is far from optimal, but until more reliable methods than the presently available is developed this is inevitable. The case study, on the other hand, has shown that the development of such a method for a particular case is not impossible even though the validity of the result can be questioned.

Loss financing

When dealing with such rare and serious events as the present tool the monetary amount is rarely of primary interest, but rather the ability of the company to handle it. Therefore is the question of loss financing of great interest. Three separate levels of damage have been identified. These are loss of liquid assets, increased dept and bankruptcy. The loss possible to withstand without increased dept is defined to be when the liquidity is equal to unity. The level above which bankruptcy is inevitable judged based on discussion with owners and financiers.

Calculations

The calculation of loss sustained is rather straight forward. The deductible or the loss sustained during the non-reimbursable period is calculated and losses that exceed the coverage or the period of indemnity are added. The uninsured losses are also added. The calculations can either be performed with Monte Carlo-technique or a simpler algebraic calculation if only intervals are used.

Presentation

The result can be presented in a chart with expected value and a 95-percent-confidence interval is noted.

Conclusions

A simple and resource lean tool for quantifying risks from machines and suppliers has been developed and compared to criteria for loss financing.

The tool has also been used in a case study. The results of the case study can not be publicly presented since the entire study is sensitive material for the company in question. A pseudo case study can though be found in the original report[5]. The tool has faced great interest from the company used in the case study and a decision has been taken to continue to work according to the method in the future.

References

1. Department of Trade and Industry (2002), "Supply Chain Vulnerablility – Executive Report", School of Management, Cranfield University
2. Båge, J., (2001). Nokia klarade branden med bravur, Dagens Industri, 2001-02-02
3. Carolyn, A., (2000). Ericsson filing million claim for production loss, Business Insurance, vol 34, issue 41, 2000
4. Överstyrelsen för Civil beredskap (1999) Säkra företagets flöden!", ISBN917097 056-4
5. Johansson, M. (2004) "Value-at-Risk"-analys av produktionskedejan – En praktisk metod för bedömning av maskin- och leverantörsrisker, Department of Technical Logistics, Lund University.

Cooperation on local and regional level of management in social crises

Tina Harrysson
Ulrika Lindmark

Abstract

This article summarises a report that represents the author's final thesis for degree in Bachelor of Science in fire safety engineering and Master of Science in risk management and safety engineering at Lund Institute of Technology. In the report, networks of coordination in crisis management are developed, together with discussion of problems in crisis management. The developed networks show the participant organisations in crisis management and on which level of decision the actors organisation work. The networks will serve as a foundation for developing practice in crisis management, but also as a foundation to establish contacts of coordination in crisis management.

Introduction

A social crisis almost always strikes a municipality. When the consequences increase in geographical range and several municipalities will be struck, the difficulties to lead and coordinate the crisis management will increase. Problems arise because of the difficulties to coordinate several actors on different levels of decision in the society, local, regional and central. There is no clear structure on how to handle cooperation and management of major social crises today.

Method

The purpose of this work is to shed light on and increase knowledge of problems in crises management and also to create a structure of the networks of cooperation that arise in social crises. A field survey among personnel from different parties involved in Skåne has been performed to create an image of the cooperation and the management. An analysis of the discharge of oil along the south coast of Skåne has also been done to serve this purpose.

Network of cooperation

The number of actors to be incorporated in the crisis management quickly rises as the affected area increases. This will lead to a complex network of actors who must coordinate their actions to achieve the best result. How the network will look like and which actors that will be involved depend to a large extent on the nature and range of the crisis. The networks of cooperation show the complexity that quickly arises in crises management. All involved actors must stay informed about what the other actors do, plan to do and what the state is and will develop to. To develop the network, we suggest that the responsibility of the County Administrative Board is increased regarding the task of giving all the actors a correct and mutual state of image.

Developed network of cooperation

The developed network of cooperation, which can be seen in the figure below, is based on all actors sending relevant information on their state of view and their actions to the County Administrative Board. After that the County Administrative Board work up and put together the information before they send it back to all actors involved, but also to actors not involved, that have to be informed. This would simplify the network of cooperation considerably and save resources for all actors since the handling of information is a large part of crisis management. The simplified network of cooperation does not imply that the actors can stop cooperating directly with each other, but that the County Administrative Board should answer for the coordination of the information between the actors. In other areas cooperation still must occur directly between the actors.

Problems in Crises Management

Besides the fact that the network of cooperation quickly becomes complex in social crises there are other problems that also ought to be shed light on. One problem is the differences in what concepts that are used and which their meanings are. We consider it important for the actors to become united on mutual meanings of the concepts to avoid misunderstandings.

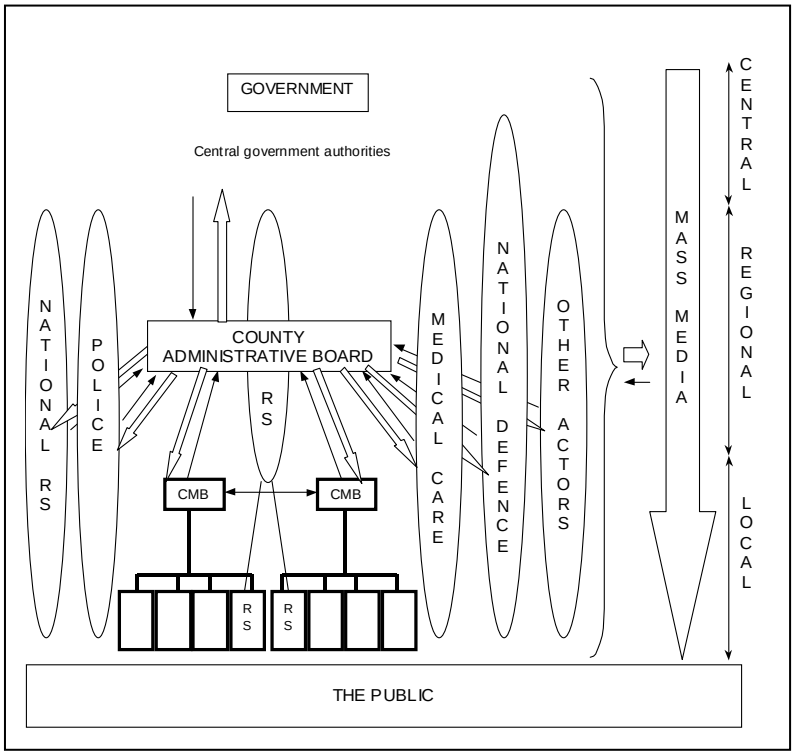


Figure. Developed network of cooperation (In t

conseq

in a coloured field of

A great deal of crisis management is based on plans. Plans are necessary but they have to be used and updated continuously. According to us the organisations should develop a satisfactory culture of crisis management to make the awareness of crisis management reach the entire organisation. A satisfactory culture of crisis management also counteracts the fact that the ability to manage crises often is bonded to only one enthusiastic person in the organisation. Another problem that has been discovered during the field survey is the indistinct distribution of roles between the municipalities and the County Administrative Board. The County Administrative Board therefore ought to make its role clear by conveying what kind of support they can contribute to the municipalities in a situation of crisis. The municipalities can on the other hand never hand over their responsibility to the County Administrative Board. Many of the problems with crisis management have their origin in the increase of distance between the actors on higher levels of decision. Among other things it is difficult to create a correct state of image for all actors and to have endurance in the crisis organisations when the need for coordinators is large. These problems could be solved if the actors used the same location of management. A common location of management is difficult to introduce but it should be seen as a vision for the future that would facilitate the management of crisis in many ways. Cooperation resolves many of the problems that arise during social crises and ought therefore to be done in different shapes and fields

Exercises

Exercises are a common form of cooperation. The networks of cooperation could be used in the planning of exercises, when they visualize which actors who may be involved in different crises and by that, which actors who ought to participate or which functions that ought to be trained. The networks of cooperation, which are based on five types of events that may trigger crises, accident, criminal action, transmission of disease, social anxiety, and infrastructure malfunction, can also act as a source of inspiration in the development of scenarios for the exercises. As for the rest it is important to consider that the exercises should be arranged pedagogically and that an evaluation should not be forgotten. This is because it is the evaluation that makes the exercise reach its purpose and lead to progress in the ability to manage crises. Well-planed exercises that feel useful may be the best way of increasing the degree of consciousness on all levels in the organisations of the actors.

Fire Prevention and Health Assessment in Hypoxic Environment – A viable method for fire prevention?

Petter Berg
Andreas Lindgren

Abstract

The main objective is to investigate if hypoxic environment is a viable fire prevention method in occupied enclosures. Hypoxic environment is a technique where the oxygen concentration is constantly reduced inside an enclosure. The purpose with the technique is to prevent fires and in case of a fire reduce the risk for fire spreading. The risks are studied and different reduced oxygen concentrations have been analysed. Suitable objects and activities are discussed which illustrate the issues and complications. The conclusions made in this study are possible to use as help when designing a hypoxic environment.

Introduction

Hypoxic environment is a technique where the oxygen concentration is constantly reduced inside an enclosure. The purpose with the technique is to prevent fires and in case of a fire reduce the risk for fire spreading. This technique is working day and night by changing the normal proportion of oxygen/nitrogen in the air. Reduced oxygen concentration will result in less oxygen and more nitrogen for a fire but also less oxygen for respiration.

The theory about using hypoxic environment as fire prevention is simple. The hypoxic environment where the oxygen concentration is reduced is unlikely to support ignition and combustion, but may still be sufficient for human respiration.

The issue with this fire prevention method is described in figure 1. The area where there is a probability of both a fire and health effects is the one of interest. This area shows clearly that there is a risk that needs to be investigated. The interactions between fire and health are complex and the size and shape of the area is uncertain. There are of course big differences between materials and humans which are associated with uncertainties.

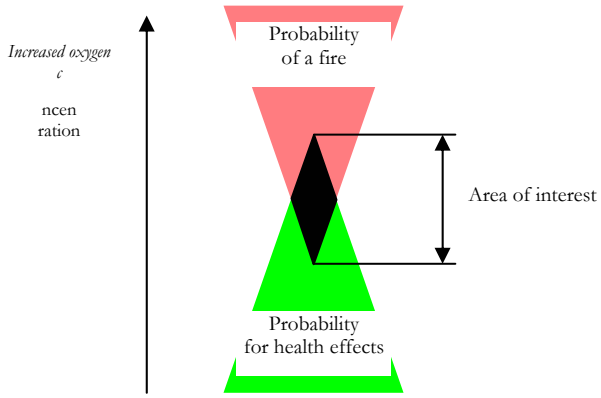


Figure 1. Description of the probability of a fire and probability of health effects.

The processes of combustion and ignition in oxygen reduced air are far different from the processes that occur in the natural environment with 21 vol% oxygen. A candle for example, can easily burn at sea level or high altitudes, but will not burn in a hypoxic environment of 16 vol% oxygen. The method where the oxygen concentration is rapidly lowered in a room by introducing an inert gas has been used for a long time for fire suppression and has proven to be effective.

Reduced oxygen concentration can be used in enclosures for fire prevention purpose where a stable atmosphere can be maintained. Today the method is for example used in fuel tanks in aircrafts to decrease the risk of explosions. Existing applications with occupants are for example submarines, computer rooms and warehouses.

It is very hard to quantify the risks related to hypoxic environment, mainly because of variations and uncertainties related to both fire behaviour and health effects. The risks are therefore discussed in a more philosophic point of view instead of being quantified.

Method

Four important areas have been studied and these are the most important to reach the

objective. There are connections between them which are illustrated with arrows.

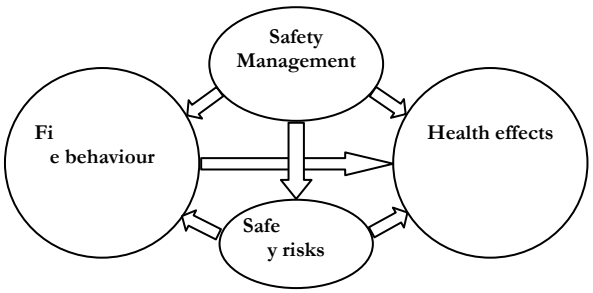


Figure 2. Important areas studied for hypoxic environment..

The probability of a fire and the probability of detrimental effects to health are illustrated in the report, which give basic knowledge for the evaluation of the combined risk between fire and health. Different parameters are discussed and analysed.

Conclusions from the four areas above and the probability relations will make it possible to study different scenarios. Moreover, it is important to know when the hypoxic environment is possible to use. Scenarios will make it possible to understand the issues and the possibilities with hypoxic environment.

Results

By reducing the oxygen concentration, the probability of ignition and combustion are reduced or even eliminated. Materials behave different during fire when reducing the oxygen concentration. Even if a fire not is prevented, the oxygen concentration is decisive for ignition, fire spread, heat release rate etc. Oxygen concentration is not the only parameter that prevents a fire. External radiation and ignition is considered to be the most significant parameters.

Figure 3 shows an example where the heat release rate is measured for three different oxygen concentrations. In this example small paper boxes are burning. The paper boxes are still burning in 15 vol% oxygen but the burning rate is considerably reduced. This experiment is performed without external radiation.

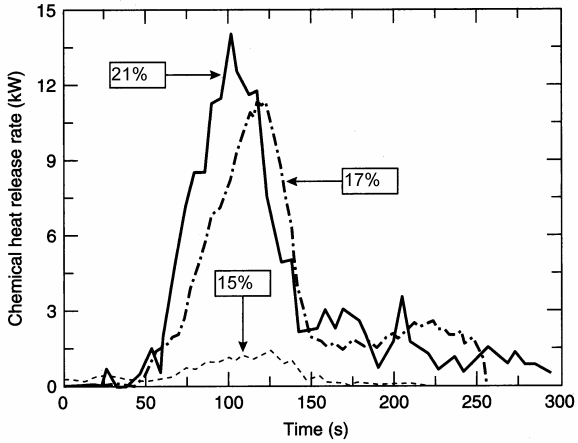


Figure 3. Heat release rate (kW) for burning paper boxes in 21, 17 and 15 vol% oxygen without external radiation [4].

Reduced oxygen concentration will result in health risks for humans. The individual differences between humans are considerable and people will suffer from symptoms at different concentrations. The symptoms are both dependent on the oxygen concentration and the exposure time.

Table 1 shows the expected symptoms on humans when reducing the oxygen concentration. These results are only valid for people with good health and the exposure time is not considered in this table.

Table 1. Summary of human effects of reduced oxygen concentration [1,2,3,5,6].

Oxygen (vol%) at sea level	Symptoms
14-21	Effects on night vision
12-21	Increased breathing, increased heart rate
12-17	Physical and intellectual performance impaired, fatigue, headache
10-14	Disorientation, faulty judgement
6-12	Nausea, vomiting
6-10	Unconsciousness
< 10	Death in minutes

Individual differences are for example due to age, sex, physical fitness and certain diseases. The exposure time is one important parameter and symptoms are more common during longer exposure. However, if the body is exposed continuously for many days in succession the body is able to manage

conditions with reduced oxygen concentration better.

Discussion

Hypoxic environment is a unique method. Today it is more and more common to work in a preventive way, but a method that actually prevents fires is unique. If a fire is prevented, life and money can be saved. The theory about hypoxic environment is simple but the application of the technique is connected with risks.

Hypoxic environment is not suited for all applications, but appears to be a good fire prevention method for certain applications. The designed oxygen concentration must be chosen with respect to humans and if any occupants will reside in the enclosure they affect the fire prevention attained by the hypoxic environment. A risk assessment and a site specific solution must be performed to achieve a minimised risk.

The most difficult judgement is when the humans are suffering from different symptoms. Individual differences are the main issue when drawing conclusions. Information sources about health effects in hypoxic air (nitrogen/oxygen mixture) is rather few, but are easier to find compared to the information in the area of fire behaviour in hypoxic air.

Monitoring of symptoms is necessary and people suffering from symptoms must leave the environment before the symptoms get worse. If the oxygen concentration drops significantly there will be a sudden change from a condition of near normality to a condition with severe effects. It is very important to be aware of this rapid change. The first most common symptom that is easy to recognise is headache and is usually followed by more severe symptoms.

There is no clear design concentration that is ideal for hypoxic environment. Fire prevention can be bought at the expense of increased health risks. There is no clear oxygen concentration where it is absolutely fire proof and there is no clear oxygen concentration where detrimental effects on health are non existent. The conclusion is that a priority must be made between the two risks.

Hypoxic environment is suited for unoccupied enclosures with good safety management and good integrity of the enclosure. Hypoxic environment will also be a possible solution for non public enclosures where safety management is excellent. For optimal function of the environment, ignition sources and flammable materials must be minimised and the integrity of the enclosure must be good. Hypoxic environments are not suited for public buildings, because the oxygen concentration could not be reduced due to the unknown health status of the occupants. Existing installations are today used in non public and unoccupied enclosures and this agrees with the research and discussion in this report.

Hypoxic environment is a sensitive technique. One big problem with hypoxic environment is when a fire actually occurs inside the enclosure. A fire is still possible, even if the probability of a fire is reduced considerably. The literature about health effects in hypoxic environment during fire is almost non-existent. The consequences of being exposed to fire gases while at the same time staying inside a hypoxic environment are probably severe. The safety margin for human health decreases when staying in a hypoxic environment. Even a small and slowly growing fire in hypoxic environment could be dangerous, especially in small enclosures. This highlights the need of a highly sensitive detection system, fire extinguishers and other fire safety equipment. Hypoxic environment will result in changes in fire behaviour such as slower fire growth, more uncombusted gases and particles and critical conditions for humans will probably occur faster.

Combustible solids have properties during fire that separates them from other materials. Some of them can develop into smouldering fires and these fires can still be present in a hypoxic environment even when flaming fires are impossible. The oxygen concentration required to prevent smouldering fires is difficult to determine but much lower concentrations are needed compared to flaming fires. The risk of fire spreading during smouldering fires is small as long as a fire not develops into flaming fire. Smouldering fires have a low burning rate and does not consume oxygen as much as flaming fires. Time to critical conditions for flaming fires are less and smouldering fires give more time for response and evacuation. A highly sensitive smoke detection system is necessary to detect a smouldering fire.

Fire prevention of flammable liquids requires lower oxygen concentration compared to combustible solids materials. Arson is often connected to liquid fires, which can act as a fire starter for combustible solids due to the added external radiation. Arson is unfortunately well represented in fire statistics and can spoil the purpose with hypoxic environment.

Safety management in hypoxic environment is very important. To make the fire prevention work as optimal as possible it can be necessary to forbid entrance for certain fuels and minimize ignition sources in the enclosure. Which materials that should be prohibited depend on material characteristic and the designed oxygen concentration in the protected enclosure. The cause of a fire could be a result of entering forbidden fuel in the enclosure or keeping a too high oxygen concentration. If this should work properly, safety management must be implemented. Policy, routines and instructions are an important part of the day to day business. Routines about what kind of materials that can be entered in the protected enclosure is necessary. In public enclosures it is not feasible to inform the people about safety instructions and health risks regarding the environment.

Homogenous mixture of oxygen and nitrogen in the protected enclosure is important. Incorrect or heterogeneous oxygen concentration may cause impact on fire prevention or health. If the oxygen concentration in the inflowing hypoxic air has a lower oxygen concentration than the predetermined design concentration there can be a gas mixture problem in the enclosure. The convection of the hypoxic air in the enclosure can be maintained with fans and with help of high velocity of the inflowing hypoxic air. Monitoring of the oxygen concentration should be carried out on many different places in the enclosure and should be measured individually.

Conclusions

Hypoxic environment have possibilities for unoccupied enclosures. No considerations are required for health aspects and therefore any oxygen concentration could be chosen. The oxygen concentration should however be chosen so that ignition is unlikely. Hypoxic environment is not recommended for public enclosures. A public enclosure is a space where the health status of the occupants is unknown. Because it is almost impossible to control the exposure time and people's health status in these spaces it is not feasible to reduce the oxygen concentration enough for prevention of fires. Hypoxic environment is possible for non-public enclosures if certain restrictions are followed regarding the health aspects of the occupants. The design concentration should be chosen as a compromise between health risks and fire risks. A priority between the two risks must be made. Decreased fire risks can be bought at the expense of increased health risks.

References

1. *ARAC FTIHWG 2001 Final Report,* Fuel Tank Inerting Harmonization Working Group, Aviation Rulemaking Advisory Committee (ARAC), June 2001

2. Kimmerle, G. (1974) *Aspects and methodology for the evaluation of toxicological parameters during fire exposure,* The Journal of Fire and Flammability Combustion Toxicology Supplement, February 1974, vol 1

3. Purser, D. (2003) *Toxicity Assessment of Combustion Products,* Section 2/Chapter 6, pp.2-83–2-171, In: DiNenno, P. J. et al, *SFPE Handbook of Fire Protection Engineering*, Third edition, National Fire Protection Association (NFPA), Quincy

4. Tewarsson, A. (2003) *Generation of Heat and Chemical Compounds,* Section 3/Chapter 4, pp.3-82–3-161, In: DiNenno, P. J. et al, *SFPE Handbook of Fire Protection Engineering*, Third edition, National Fire Protection Association (NFPA), Quincy

5. www.osha.gov/SLTC/smallbusiness/sec12.html, Occupational Safety & Health Administration (OSHA), 17th June 2004

6. www.trconsultinggroup.com/safety/last.html, T.R. Consulting Inc., 30th April 2004

Survey and assessment of safety culture – a method proposal and the application of the model on two companies within the process industry

Matilda Börjesson

Abstract

The result of the work conducted is a method to evaluate and map the safety culture within a company. The method consists of two general templates. The first template, refered to as the assessment template, works as a reference point. The second one is a presentation template where the facts and status of the company in focus will be presented and evaluated compared to the assessment template. Safety culture relates to attitudes, behaviour, norms and values concerning safety. In this report nine key areas will work as a starting point. The nine areas that together state the core values of safety culture are: working conditions, flexibility, communication, reporting, justice, learning, attitudes concerning safety, behaviour concerning safety and risk perception These nine areas will also act as the foundation for the templates. Further, the report contains an evaluation of the method to survey and assess the safety culture as well as an example of how the method can be used in practise. In this case the technique is performed at two companies within the process industry. In short, the templates work satisfactory as a practical tool and creates structure for the survey and assessment of safety culture.

Introduction

It is more important now then ever to work in a preventive way with accident control. The first thing that comes in to mind when considering precautionary measures is often to improve the existing physical safety features. For example install a sprinkler system or buy new, safer clothing. However, it is important to keep in mind that this is merely one part of the complete picture. Almost 80 % of all accidents are caused by the human factor and one way to deal with this, "softer" side can be to implement or improve an already existing safety culture.

Safety Culture

A high-quality safety culture is, in essence, a safety thinking rooted within the company, from management to employees, to avoid and minimize unnecessary risk taking. The safety culture reflects the attitudes and behaviours that exist inside the company and a successful organization has safety as one of its core values.

The different safety barriers of the "softer" side can be described in the same way as for ordinary technical systems, see figure 1. Accordingly a company has many safety barriers but the most fundamental one is safety culture.

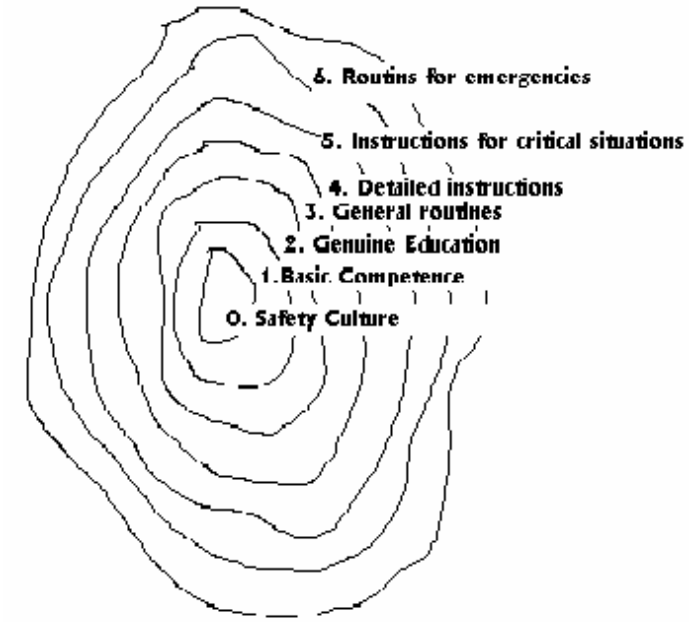


Figure 1, Exampel of "soft" safety barriers within a company where the inner circle is safety culture.

This shows that it is safety culture that is the inner circle, the first barrier to prevent anything unwanted to occur within the premises. This means that under idealistic circumstances, theoretically, a good safety culture is all that it takes. No other systems are needed if the company really is pervaded by an excellent safety culture.

On the other hand, if the safety culture that is the inner circle is missing it doesn't matter how many outer layers, good competence,

routines for emergency etc., there will be. Because if there doesn't exist a good safety culture nobody will follow the routines and the instructions and nobody will have safety in the back of their mind while performing their daily tasks or working with the company's strategy.

If there is a good safety culture within a company everyone is aware of the importance of having safety in focus. The result will be that both active and latent errors will be minimized by the fact that safety always is the number one priority.

However, human errors will always exist, it is in her nature. So by achieving a good safety culture much is won, it is one of the most effective ways to work preventive for accident control, but it not enough. It always has to be completed with technical safety barriers, the "hard" side, if an accident occurs. Human errors must be permitted and be able to manage within the frame of the system where the work is done.

Method and templates

Thus safety culture relates to attitudes, behaviour, norms and values concerning safety and in this report nine areas had been used as the foundation when expressing the safety culture. The same nine areas has also acted as the starting point when designing the assessment and presentation templates. The nine areas that originally are expressed by Åsa Ek PhD, Lunds University are: working conditions, flexibility, communication, reporting, justice, learning, attitudes concerning safety, behaviour concerning safety and risk perception.

But how do you approach a broad area like safety culture? To be able to get the overall picture a template, based on Kemikontorets report for revision of SHE (safety, health and environment), was created. The purpose of the template was threefold; (1) To survey the safety culture, (2) to be an instrument for mapping and assessment and (3) to provide and overview of the current status of the safety culture relating to the nine key areas.

	Insufficient, 2p	Shoud be improved, 4p	Good, 7p	Excellent, 10p
Stress	Experiences that the demands exceed the ability ones capacity. The feeling of not having enough time is overwhelming and will last during long periods of time.	One feels stressed during shorter periods. The feeling of being insufficient is there from time to time. There is not enough support from superiors.	Feels very rarely stressed during work. Experience thet there is enough resources avaliable to be able to cope with the demands.	Doesn´t feel any negative stress from the job. There is enough time to achieve the goals and good support from superiours whenever it´s needed.

Figure 2, A short example of the presentation template.

The main example study was performed at the ethylene oxide plant at Akzo Nobel Functional Chemicals and at the pulp mill at Södra Cell Värö. It is important to stress this delimitation of the report, since further and more in depth studies has to be made in order to comment on the safety culture of the entire organizations.

To be able to use the templates in the correct way it is important to find information from the companies to apply to the templates. Therefore it is important to do a solid and thorough investigation. In this report three different methods where used: interviews, questionnaires and indicators.

OECD gives great guidance of how to find useful indicators in their new book, OECD guidance on Safety Performance Indicators. To be able to get overall picture of the safety culture within the given company it is important to include all levels of employees in the study. It is also vital that the project leader has a deep understanding of safety culture.

Findings

The work conducted suggested that a healthy safety culture existed in the ethylene oxide plant and that the culture was firmly rooted within the company. However, some
weak links existed and it is important to stress that constant work is needed to make sure that

the current level of safety culture is maintained and kept up to date.

The survey and assessment of safety culture of the pulp mill at Södra Cell Värö showed that safety matters were taken into account on all levels that were under scrutiny in this report. However, more time and effort is needed before they will achieve a good safety culture that is embedded in all levels within the company. If the work continues in the same direction as today the company will achieve an increase in safety thinking and finally attain a good safety culture.

A warning that applies to both companies is to not put the production alone in focus. Instead it is important to let safety be a core value and to truly understand that a safe plant also is favourable in an economic perspective.

The final conclusions of this report are that the created templates work well for its designated purpose i.e. to assist in understanding, surveying as well as assessing the safety culture within a company.

Risk management in Hvalfjörður Tunnel

Gudni Palsson

Abstract

The thesis is about how risks in Hvalfjörður Tunnel can or should perhaps be managed. Risk from collisions, vehicle fire and vehicles transporting dangerous goods accidents in the tunnel were quantified. Frequencies were estimated using mostly historical data. Models to estimate consequences from these risks were then built by calculating physical effects and measuring their effects on people evacuating the tunnel. Account for uncertainty was addressed thoroughly by performing Monte Carlo Analysis. Results from the analysis were compared to different criteria. Other ways to make rational decisions regarding risks were discussed. The question on how risks can be decreased or controlled was also briefly examined. Finally there is a discussion, both on actual results on risks in Hvalfjörður Tunnel and on the methodology used to quantify these risks.

Introduction

The thesis represents the author's Master's thesis in Risk Management at Lund University.

In Iceland, a road tunnel called Hvalfjörður Tunnel, built according to Norwegian standards, has concerned many from the day it opened. Previous risk analyses for Hvalfjörður Tunnel were carried out without calculating physical effects from fires. These analyses did not include any extensive uncertainty analysis. Over the last few years' research on this subject have addressed many issues; including research on what scenarios can be expected and tools to calculate consequences from these. It is therefore possible to carry out much more advanced risk analysis now than was perhaps possible a few years ago.

The risk management process

The proposed management procedure is shown in Figure 1. What this figure shows is perhaps generally the working process for almost all hazards which need a careful examination.

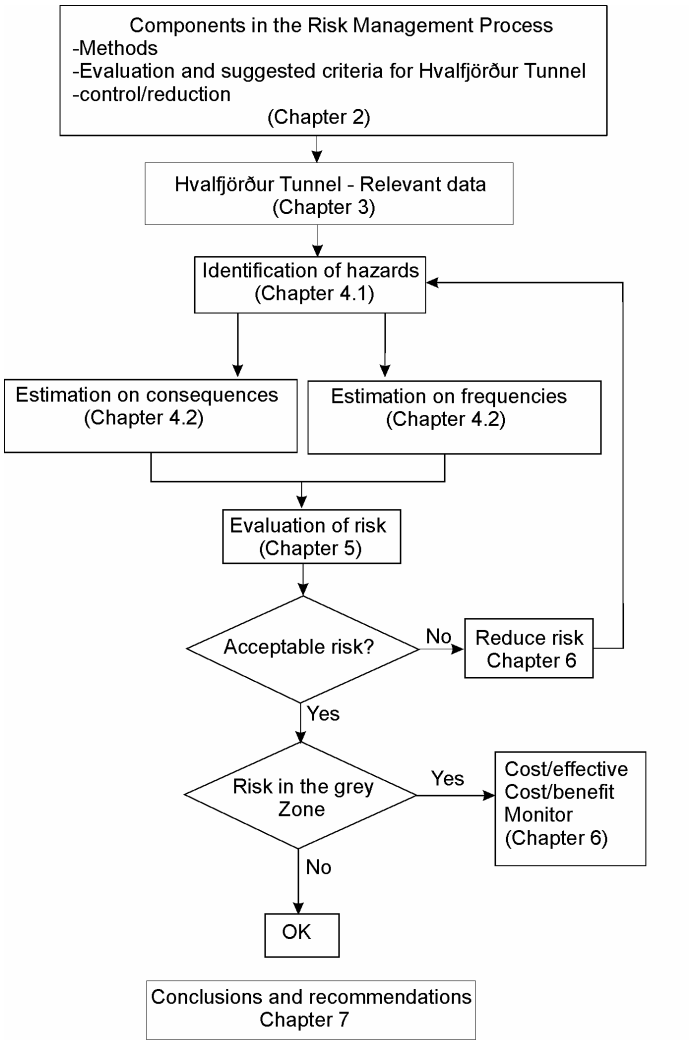


Figure 1. The risk management process for Hvalfjörður Tunnel.

Almost all steps in the process are straightforward, meaning they can be quantified objectively. But when it comes to subjective matters, difficulties arises quickly. Perhaps the most debated and hardest step to quantify involves people's perception, the level of acceptable risk. How risky can an object be? Does the benefit it brings matter? A literature study showed that these questions matter a lot and people's perceptions should not be underestimated. Effecting people's perceptions effects also the acceptability.

Risk assessment for the tunnel

In the thesis, collision, fires in passenger vehicles and heavy vehicles and consequences

from various dangerous goods accidents were quantified. Uncertainties in values for most variables were incorporated through modelling and by performing a so called Monte Carlo Analysis which resulted in a wide range of results, revealing the uncertainty involved.

Results were interpreted as individual risk and societal risk and then compared to criteria set by the British Health and Safety executive (HSE), Det Norske Veritas and the Norwegian Public Traffic Administration. A new criteria, based on historic levels of traffic accidents, was also proposed but the purpose of that was more to show how a new criteria can be constructed.

Societal risk was only found to be tolerable compared to HSE criteria but unacceptable compared to all other societal criteria. Individual risk was found to be acceptable in 2 out of 4 of the proposed criteria.

The results showed also that risk could be judged acceptable depending on which units were used. If presented in the units per trip or yearly risk, risk could be judged as acceptable but if presented in the unit per travelled km risk was found to be unacceptable. Table 1 and 2 and Figure 2 and 3 show the individual and societal risk compared to their respective criteria.

Table 1. Different individual risk critera´s compared to individual risk in Hvalfjörður Tunnel.

Criteria no.	Individual criteria's	Risk of fatality per	Average risk	5-95% confidence interval	Risk passes criteria
1	1.0E-05	year	5.7E-06	*(2.8E-06 - 1.4E-05)*	Yes
2	78	100 million trips	13	*(6.3 - 31.0)*	Yes
3	1.3	100 million vehicle km	2.3	*(1.1 - 5.4)*	No
4	0.6	100 million person km	0.9	*(0.4 - 2.1)*	No

Table 2. Expected value for statistical fatalities given in yers

	5% quartile	Average	95% quartile
Expected value (all risks)	0.083	0.172	0.407
Expected value (all risks exclusive collision risks)	0.00003	0.073	0.292
Return period (in years, all risks)	12	6	2
Return period (in years, all risks exclusive collision risks)	29157	14	3

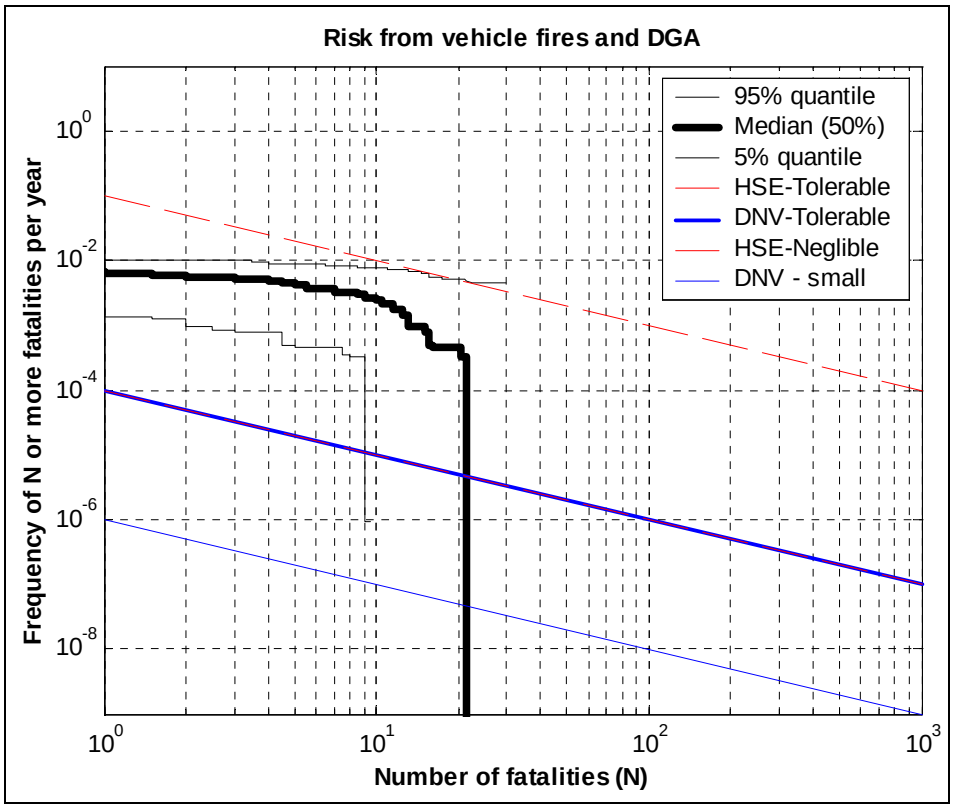


Figure 2. FN curves showing risk compared to limits set by the British Health and Safety Executive (HSE) and DNV.

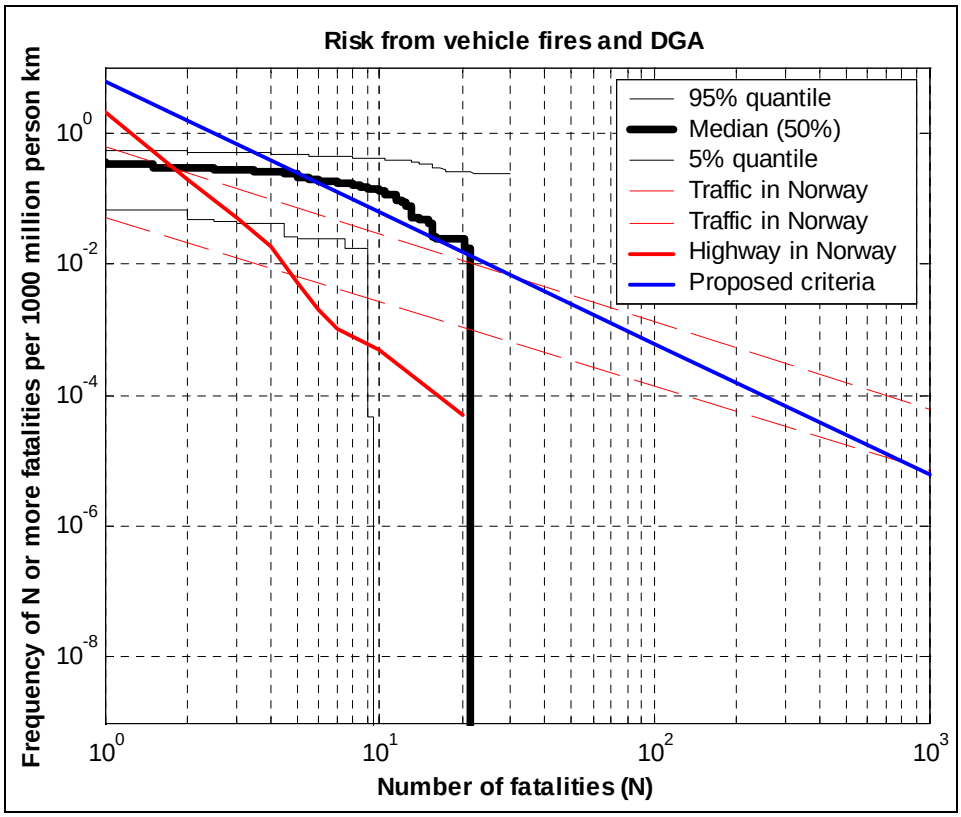


Figure 3. FN curves showing risk compared to limits set by the Norwegian Public Road Administration (Statens Vegvesen).

Conclusions

Criteria to evaluate the acceptability of risk were indeed available but which exactly is the most appropriate one was however not so easily answered. This should perhaps be a task for authorities to work on. It is however obvious that risk is rather high and means to lower the risk should be taken. This means also that the Norwegian standard, the tunnel was constructed by, is hardly good enough. These results prove also that future tunnels need to be analysed thoroughly prior to their construction. Installing safety features in an already and operational tunnel is likely to be more expensive than if they had been planned in the early process.

The method used in this thesis, sometimes referred as extended Quantitative Risk Analysis or Probabilistic Risk Analysis, proved to be a good tool to evaluate risks in tunnels. Using Monte Carlo Analysis showed also that the uncertainty is very great. Doing a single point analysis must thus be carefully chosen and described. However if resources are to be used effectively then risk analyses need to be complemented with other tools like cost benefit analysis and cost effective analysis. Economical methods involve however also other problems, like the price of human live.

Different ways to lower the risk were presented briefly but only as a list of different ideas which should be evaluated in the near future. A proposal of how they should be evaluated was however described.

It was recommended that the tunnel owner implements some safety management system to monitor and detect changes in the current risk level and to ensure that all safety features will work when they are needed.

Statistical determination of ignition frequency

Martin Sandberg

Abstract

The frequency of ignition is an important variable in the quantification of risk. Actual data and models used for the prediction of the frequency of ignition are now becoming quite dated. In this study, general theoretical models are developed of how the frequency of ignition can be applied depending on the data available. The data collected will allows more closely to examine the frequency of ignition and to apply the developed models.

Introduction

The building construction's technology has changed since the first models for predicting the ignition frequency were developed. Different factors such as the building materials and more innovative design of buildings have changed. The frequency of ignition is an important variable in the quantification of risk. The data used for the prediction of ignition is now becoming quite dated. Therefore there is a need for research in this area.

The aim was to review and update the model and data for the prediction of ignition frequency. To achieve this objective I had to identify and review the existing models and data. Another of my task that was undertaken was to identify factors that affect the frequency of ignition.

In this paper, when applying statistical methods, general theoretical models will be developed of how the frequency of ignition can be applied depending of the data available. These methods do not have any link to any country and can be applied worldwide.

Data will be collected from Sweden and Denmark to examine the ignition frequency more closely. The results can be a general pointer for further research or applied when quantifying the frequency of ignition of a building.

The research covers non-domestic building types.

Analysis and evaluation of the topic

The Master's thesis begins with a brief analysis of the topic. In this section, I attempt to elucidate the importance of ignition frequency as a part of risk. Even though the frequency of ignition is an important variable in the quantification of risk, little research has been done on the topic.

Determination of the frequency is a part of the risk analysis process. The ignition frequency is a parameter of great uncertainty in a risk analysis particularly because the data available for the prediction of ignition is quite dated.

Frequency and *ignition* are the two expressions commonly termed. Often frequency is said to be the probability that an event will happen over a period of time and ignition initiation of combustion. A convenient way of terming frequency is to say that it is a rate of occurance or repetition of something and ignition is a fire event to which a public fire department has been called.

The frequency of ignition denoted by λ [1/y] consists of the average number of fires that is expected during a time unit (usually a year). The number of fires depends on the nature and the amount of ignition sources present in a building, the latter increasing with the size (floor area) of a building. Hence, one can express the frequency of ignition as λ(a) [1/y] which assumes that λ will depend on the area of a building. A simple model can express this:

$$\lambda(a) = c_1 a^{c_2}$$

where a is the total floor area (m^2) of the building and c_1 and c_2 are constants for buildings of different occupancies.

Comparative case study analysis

G. Ramachandran and R. Rutstein are the two more recognized in the United Kingdom that wrote on the frequency of ignition. The data presented is quite dated but the models are frequently applied in many fire risk projects.

The occurrence of fire in a building one cannot specify and control all the factors affecting. However, one can determine the relative contribution of some of the factors.

Even though it is difficult to determine the exact risk of an object, a way to provide an approximate solution to the problem is to consider frequency of ignition as an uncertain value and express it as a stochastic variable.

To assess the risk of a particular building one needs to collect and analyse data pertaining to buildings with similar fire risks. The result of an overall analysis can be applied to assess the basis of fire risk in any particular property.

Ramachandran claims that the probability of fire starting depends on the nature and amount of ignition sources present in a building. The amount of ignition sources increases with the size of the building and therefore the probability is dependent on the size. Other factors such as human activity, equipment faults or natural phenomena may as well affect the ignition frequency. Indeed, a number of deliberate ignitions are part of daily routines (e.g. when you start the car), despite only a small fraction of these may become uncontrolled. In similar way buildings' equipment have a potential to ignite when energized. Per capita, the number of equipment that ignite is fairly constant.

In Finland quite new data has been collected using a considerable large amount of data. A new model shows that the frequency of ignition is dependent of the floor area. The sweeping generalizations made in this model limit its use. Indeed, the authors group different occupancies that have close values.

Fire frequency and social structure

A technical approach of fire frequency is often applied when studies of the topic are carried out. Another approach can be performed when looking at the social structure of country or a small region. The objective was to explain the fire risk structure in Sweden by studying social, demographical and economical variables. These variables are as important as technical questions when one wants to decrease the fire frequency. Nevertheless, this kind of study gives better results for residential buildings because of their relative homogeneity group.

The application of statistical methods in fire risk research

In risk analyses classes of distribution are often used as an application when one has to model the uncertainties. There are two different schools when predicting of future events, the frequentist and the Bayesian approach. The main difference between the frequentist and the Bayesian approach to statistics is that the first one considers parameters in distributions describing the data as unknown constants while the Bayesian tells that since parameters are unknown their values can be described using distributions. They are deeply different and the former can never replace the latter. Frequentists read data and make large volumes of statistical observations understandable using simplifying distributions as analytical mathematical forms. Bayesian approach tries to include ignorance. Some people have long rejected the whole idea, but in situations when little data is available it is a good method. For large data sets both methods work equivalently well.

Applying the frequentist approach the Maximum Likelihood Method is a very common, popular and useful method to estimate parameters because of its applications. Since most models do not fit exactly the data one needs to look for parameter estimates that maximize the likelihood that the model fits the data.

Dependent on the situation, the data and the material available (programs, computers, etc.) statisticians may use different methods to determine the frequency of ignition.

The first method based on the Maximum Likelihood Estimator is used when data is available both for buildings at risk and buildings where a fire has been recorded. In an ideal world, this method should be favoured over other ones because of its accurate level. The problem though is to get hold of all necessary data. Nationally this kind of information is not often collected and insurance companies, which may hold the data do not spread this kind of information.

The second method, also based on the Maximum Likelihood Estimator, is applied when data is available only for buildings where a fire has been recorded. Information about buildings at risk, which have not been involved in a fire, may therefore not exist.

A man named Ramachandran developed the third method. His model has a worldwide

acceptance but it is expressed in a way that makes it difficult to put into practice. Consequently, I have tried to display and improve the model.

The fourth and last method is named Bayesian data analysis. The application of Bayesian approach is suitable when there is not much information given e.g. the safety of a nuclear power plant. This method should be reserved for low-probability, high-consequence events.

Frequency of ignition – Sweden

An average ignition frequency can be estimated in different occupancies which have been performed in this study. More interesting though is to collect data of individual buildings in different building categories and estimate parameters. In this study, generalized theoretical models were developed of how the frequency of ignition can be applied depending on the data available. Data were collected to examine the frequency of ignition more closely and to apply the models. The result from this kind of probabilistic modelling is very useful in engineering design and the Master's thesis shed new light on the topic.

Discussion

The results presented in the Master's thesis will hopefully inspire future work on the topic applying the developed methods for different situations. More collaboration between different associations, national rescue service agencies, insurance companies etc., would definitely help to compile more statistics. More statistics available would give better estimations of parameters.

If each country would nationally collect all the necessary data, the information provided would decrease the uncertainties and consequently the ignition frequency as a part of a risk analysis would be more credible.

A model for designing municipal fire services

Rima Adawi
Karin Johansson

Abstract

For a very long time the municipal fire services in Sweden have been formed due to tradition and different laws. This design does not take the actual risks in the municipal into consideration. The purpose of this report is therefore to create a model for designing municipal fire services. This model will take more factors into consideration than the population structure as has been done before.

Introduction

For the last couple of decades the application of Swedish fire legislation has contained norms for operational times of ten, twenty or thirty minutes. These norms are mainly based on population density. The norms for certain operational times along with demands on BA rescue and informal factors, such as safety and local political demands have been and still are to some extent crucial for the design of Swedish fire services. Malmö fire service is one of the fire services in Sweden that has realised that there is a need for changing and developing municipal fire services. This mainly because they consider the old methodology to be associated with a lot of problems but also because Malmö fire service is now in the midst of joining a fire service union in south west of Skåne.

A majority of European countries are currently working on developing risk based methods for customizing fire services. In this thesis the methods that are being developed in Denmark, Norway, Great Britain and Germany have been contemplated. In these risk based methods tools like risk- and vulnerability analysis are important aids when mapping out the risk profile of a municipal. Certain questions have constantly returned in the studies of the chosen countries methods. For example questions like which society values should be protected and which objects are identified as vulnerable along with how the fire services can be customized on the basis of the citizens need.

Methods for designing municipal fire services

The Danish fire services are currently customized on the basis of rules which have been established on a central level. The biggest problem with this method has been that too many decisions about the local fire services have been made on a central level. This is the main reason why a more risk based methodology currently is being developed in Denmark. The main purposes with this new risk based approach is to create more local influences and to make the methods within the municipal more goal oriented. At the same time preventional work and collection of data will get greater parts together with increased cooperation within the municipal.

In Norwegian fire legislation there are norms, similar to Swedish norms, for operational times. However, nowadays it is mainly the municipal that makes the decisions about which resources to allot the fire service. The basis for the design is therefore the risks and vulnerabilities of an individual municipal. The central "Direktoratet for samfunnssikkerhet og beredskap", DSB, has established a minimum requirement which is based on general risks for densely built-up areas, population size and different object's demands on operational time. The purpose of this minimum requirement is to secure the communities preventional work and maintain an effective fire service with adequate competence and equipment. This means that the Norwegian fire services are designed on both a mapping of the community's risks and vulnerability and on the central minimum requirements

One of the countries that have reached far with risk based design of municipal fire services is Great Britain. For nearly sixty years the municipal fire services in Great Britain have been governed by prescriptive fire legislation based on building density. This legislation was considered to be very prescriptive and very few decisions about the municipal fire services were made locally in the communities. This is the reason why an

independent review of the fire services in Great Britain was carried out. This review has led to the development of new fire legislation and a more risk based approach to the design of fire services. The new fire legislation transfers a lot of the responsibility for the municipal fire service from a central level to a local. To support the communities in the risk based design of the fire service a toolkit, known as the FSEC toolkit, has been developed. This toolkit can be used to assess the risks of a municipal, make decisions about resource allocation on the basis of the risks and at the same time estimate the consequences of a certain resource allocation.

Germany is a country divided into different Federal Republics and every Federal Republic has its own fire legislation to control the design of the fire service. To create a more exhaustive fire service many Federal Republics have chosen to merge into different fire service unions together with other Federal Republics. A great benefit with creating collaboration between Federal Republics is an improved use of resources which in the long run can get positive financial effect. Most of the contemplated methods that are being used in Germany are based on some kind of risk analysis. The purpose of using risk analysis as a tool is, according to German fire services, to distribute the fire service's resources on the basis of the risks.

Our model for designing municipal fire services

In figure 1 we present our model for designing municipal fire services. The model begins by defining the objectives for the accident protection within the municipal. The reason for this is that we want the municipal to be able to identify which participants besides the local fire service that should have a part in the accident protection. The fire service is mainly a participant during the accident but there are also participants whose, work before and after, can affect the probability and consequence of an accident. When the connection between before, during and after participants has been understood it will be easier to set the objectives for the municipal fire service. The objectives for the fire service should comply with legislation, but also with the overall obvectives within the municipal. When all objectives have been identified it is time to document a description of the current situation in the municipal. This description should contain information about population structure, landscape structure, infrastructure and so on. The next step is to perform a coordinated analysis of vulnerable objects, risks and help needs within the municipal. We think that this analysis can be performed in connection to a discussion seminar, were people from different agencies within the municipal together will create typical examples of accident that the fire services have to manage. When these typical examples of accidents are created the next step is to identify critical factors for each typical example. These factors are critical in the sense that they will decide the outcome of the management of the fire service. For example, in the case of a drowning accident one critical factor will be time. The earlier the fire service arrives, the more successful their management of the situation will be. When different typical examples of accidents have been created and critical factors have been identified the municipal will have enough information for deciding which resources are needed for a successful management of the typical examples of accidents. This model is to a large extent based on local data and for this reason the work according to this model has to be evaluated, updated and improved as the municipal changes.

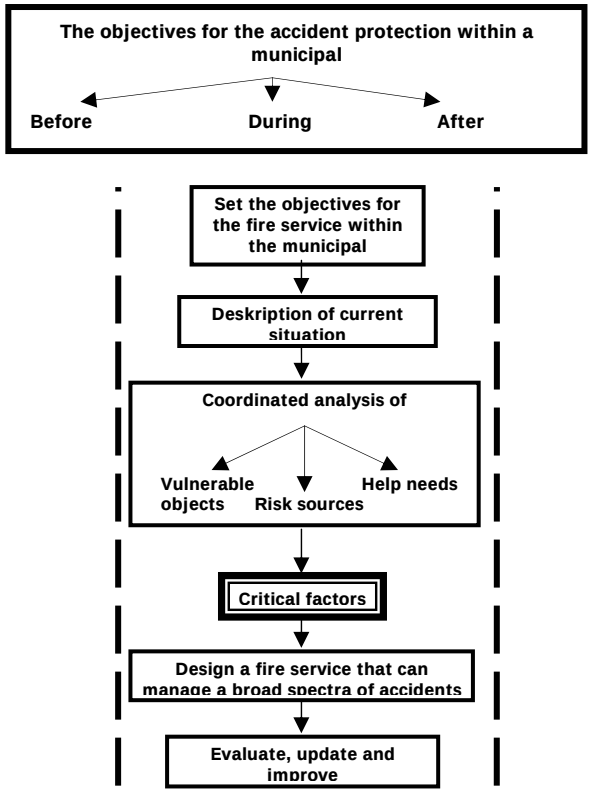


Figure 1: Model for designing municipal fire services.

Conclusions & discussion

We consider that other factors than just population density have to be regarded when designing municipal fire services. By letting aspects such as risks, vulnerable objects and human help needs be the basis for designing fire services, the actual dangers that threaten a municipal will be taken into account for. We suggest that a coordinated analysis of these aspects should be carried out. The result of this analysis will be typical examples of accidents that the fire service needs to manage. From these typical examples of accidents critical factors then can be identified. We think it is important to identify critical factors such as time, flexibility and management, which are considered to have a great importance in creating a satisfying management of an accident. According to us the main benefit of letting the coordinated analysis to be the basis for designing the fire service is a better use of the fire service's resources. By constantly evaluating and updating the critical factors and letting the fire service follow the development in the society we think that the municipal fire services can be made more efficient.

On the basis of the problems associated with today's design of fire services in Sweden and the studies of different European design methods a model for customizing municipal fire services has been developed by the authors of this report. This model will hopefully lead to putting the citizens in focus for the fire service. In other words we think that the fire services should be designed on the basis of the citizens´ help needs. An important step in working with this model is to see prevention and intervention as complements to each other. Finally we want to point out that more practical tools are required before the model can be used in practice by "Samverkan Skåne SydVäst", SSSV.

Practical applications for utility functions in fire safety investments

Elisabeth Altin
Johanna Mola

Abstract

How can utility be taken into consideration in fire safety investments? This project will hopefully present one way to do this in decisions concerning fire safety. Theoretical methods are presented and a case study is carried out to illustrate how the theoretical models can be used in an investment situation.

This project is a master thesis, which has the over all aim to show how consideration can be taken to utility when decisions in fire safety are made. The objective is to apply the theory in a case study at the Volvo Aero plant in Trollhättan. The project has been carried out in co-operation with Volvo Aero Corporation and Lund's Institute of Technology. Due to the large range of different kinds of safety investments and the cover of the Volvo Aero Plant in Trollhättan, the case study has been limited to a sprinkler system investment in one workshop at the Volvo Aero plant in Trollhättan.

Today the competition between companies is tough and it is getting even tougher. Therefore a company that wants to act at their top level requires high-level safety work and a very high reliability. By prioritising risk management, a company can increase the reliability and lower the expected damage cost that follows an extensive fire. Nevertheless, a prioritised risk management is associated with costs and each investment alternative has to be carefully put in relation to the risk reduction that follows. To fully examine the value of an investment, many factors have to be taken into consideration. In addition to savings in the insurance costs and the reduction in expected loss costs, the risk reduction can have an emotional value to the decision maker. This utility value is abstract and cannot be easily quantified. By revealing the company's utility function, which describes its attitude towards risk taking, the utility can be converted into a monetary value.

Today many decisions are based on previous results and intuition and no particular value is given to the utility of the risk reduction. Hence, it's not sufficient to make decisions in the same way that they have always been made, some questions at issue are therefore to be addressed. The over all question is *how utility can bee taken into consideration in decisions about fire safety?* To be able to answer this, the question is divided into a number of minor questions.

How can a utility function for a company be revealed? To be able to decide on which method to use to reveal the companies utility function a summary of present models, based on literature studies, was made. Based on this we reached the conclusion that a Certainty Equivalence Method would be the most reliable method. The Certainty Equivalence Method is based on the premise that an individual can state a specific outcome, the certainty equivalent, for which he or she is indifferent between taking part in a specific lottery or achieving, alternatively paying, the certainty amount. There are other more complicated models to reveal a utility function, that in theory would give a better result, but our conclusions are that these models would be too difficult for the respondent to relate to. Therefore we made the judgement that the result would be better if we used a simpler method, even though certain biases are associated with the model.

To estimate the utility function we selected four decision makers from Volvo Aero. By using the Certainty Equivalence Method we were able to determine the monetary values corresponding to the utility of different loss situations that each respondent was asked to estimate. These monetary values were plotted in a diagram and used to interpolate each decision makers utility function.

The investigation resulted in four utility functions, one for each decision maker. Our results show that the characteristics of the utility function entirely depends on the single decision maker's attitude towards risk taking. Therefore it can be hard to determine a company's utility function. To do this the management has to sit down and together decide on a common policy.

To illustrate how a company's attitude towards risk taking can be taken into consideration in an actual decision situation, a case study was carried out on the Volvo Aero Corporation plant in Trollhättan. The main steps in the case study are *risk identification, risk evaluation* and an *investment appraisal*. The result is adjusted according to the case company's attitude towards risk taking.

The *Risk identification* was based on a survey of the present situation at the A-workshop and the purpose was to identify possible fire scenarios in the production area. The survey was carried out in co-operation with Volvo Aero's fire manager and resulted in ten different fire scenarios. The survey comprises the present situation concerning fire safety, risk management that can affect the fire safety and the kind of activity carried out. To get an overview, risk management documents were studied and interviews were carried out with among others, the safety manager, fire manager and the insurance manager

Risk evaluation consists of several different parts. To evaluate each of the ten risk scenarios that were identified, the consequence of each scenario has to be determined as well as the probability of it. The expected damage costs are an evaluation of the probability that a particular consequence will occur and the value of that specific consequence.

The consequences were measured in damage costs and the insurance manager at Volvo Aero estimated the damage cost of each scenario based on the survey of the workshop that was carried out in co-operation with the fire safety manager at Volvo Aero.

To determine the probabilities for each of the parameters included in the event tree, general statistics were used to as large an extent as possible. For some of the parameters the statistics were insufficient, which leads to another question:

How can expert judgements be used when the statistical material is insufficient? There are no available statistics for the probability of the employees extinguishing a certain fire. Therefore expert judgements were used to predict the probability values. All the persons interviewed are employees of the Swedish Rescue Service and they were chosen with respect to their experience and knowledge in fire extinguishing and fire safety. This approach was chosen because we made the judgement that these persons would have a good ability to predict the capability of the employees.

The interviews were performed at the interviewee's normal work place and the purpose for this was that it would generate a more relaxed environment. All the interviews were structured and planned ahead. The questionnaire is based on the particular field of activity in the workshop and the object is to give a clear picture of the basic conditions to minimize the risk for different interpretations.

It's hard to say whether the results from the investigation are reasonable, but as there is no other information available about the probability and our judgements is that the result can be used as a guideline in other analyses.

The investment appraisal is based on the investment costs of the sprinkler system put in relation to savings in insurance costs and reduction in the expected loss costs. The costs are estimated based on a previous sprinkler system installation in a comparable workshop at the Volvo Aero plant, and the expected cost caused by a fire with and without a sprinkler system is determined from the risk evaluation.

The investment appraisal shows that an investment in fire safety can incur large savings in the expected damage costs, even for companies with an already high safety level. The size of the expected savings is however related to the current safety level in the shop. When these steps have been carried out, the most important question can be answered:

How can an adjustment of the result from the investment appraisal be made according to the companies attitude towards risk taking? This question is to be answered based on the case study. The first step to answer this question is to determine the expected utility of the risk reduction caused by the sprinkler investment. By using the company's utility function the expected utility of the investment can be given a monetary value. adjusted to the companies attitude towards risk taking. By using this value as a savings in the investment appraisal the value of the investment can be

From a risk neutral point of view, the value of the investment remains the same, but if the adjustment is made with a risk seeking utility function, the value of the investment will decrease. It is likely to get this kind of risk seeking utility functions when the investigation is based on very large losses.

The most important conclusion from this project is that different decision makers in a company have different attitudes towards risk taking and that this largely can affect the decisions that are made. To unite the decision makers, the company has to make a consequent policy for risk taking in the company.

A conclusion of the case study is that the even companies with an already high safety level can benefit substantially from further investments in safety. In Volvo Aero's case the investment appraisal resulted in a positive value of the investment, and the conclusion is therefore, that the company should go through with the investment.

Environmental and health effects from fire fighting exercises of the Swedish Rescue Services

Kerstin Eriksson
Emma Rengbo

Abstract

The Swedish Rescue Services Agency (SRSA) has been administered an area of responsibility for the sector "Prevention of accidents" ("*Skydd mot olyckor*"). The area of responsibility means that SRSA should report the total effects on the environment caused by activities within the sector. They should also try to work towards a sustainable ecological development according to the Swedish environmental objectives. A first step to achieve the goals within the sector "Prevention of accidents" is to quantify the emissions from the rescue services´ fire fighting exercises and to estimate their potential adverse effects on the environment. Environmental aspects are strongly related to health hazards and therefore are also taken into account in this thesis.

The main purpose of this work was to perform an overall risk assessment of the annual emissions from the Swedish Rescue Services´ fire fighting exercises with regards to effects on environment and health.

Fires are complex phenomena and it is difficult to estimate emissions when they are uncontrolled. Locally the emissions from fires can be severe and because of oxygen storages large amounts of toxic compounds are normally generated.

In addition to accidental fires the rescue services perform extensive fire fighting exercises all over the country. Emissions from the rescue services´ training are, until today, poorly investigated and there is therefore a need for analysis of this kind of activity. Because of the Swedish Parliament's environmental resolution to work towards an ecologically sustainable development, health and environmental issues are prioritized by the SRSA.

The aim of this project is to come up with suggestions to decrease the environmental and health impact of emissions from fire fighting exercises. The project shall also provide basic data for further studies on the emissions generated from accidental fires and their adverse effects on environment and health.

Methodology

Experimental tests were performed during a common fire fighting exercise, where emission yields for six common fuels were estimated. The carbon monoxide, carbon dioxide and particles yields, which were calculated from the experimental test data, were comparable to the yields given in previous studies.

Results

Common fuels used in fire fighting exercises by the Swedish Rescue Services are:

- Euro pellets (wood)
- Particle board
- Diesel, Gasoline,
- Bio diesel 101 (a mixture between diesel (50-100 %) and raps seed oil (0-50 %))

In the following figures, figure 1 and figure 2, the total annual emissions from the Swedish Rescue Services fire fighting exercises are presented. Each colour bar in the diagrams represents a method by which the fuel consumption was estimated.

The methods used in the estimation of the total fuel consumption are as follows:

Method 1 (grey bar)

In method 1 the estimated fuel consumption was related to the percent of the rescue services, which answered the questionnaire.

$$\text{Tot. fuel consumption} = \frac{\text{Tot. fuel consumption by the rescue services in the survey which answered the questionnair}}{\text{Percent of the total number of rescue services in Sweden which answered the questionnaire}}$$

Method 2 (black bar)

In method 2 the estimated fuel consumption was related to the population of Sweden.

$$\text{Tot. fuel consumption} = \frac{\text{Tot. fuel consumption by the rescue services which answered}}{\text{Numb. inhabitants in municipals of the anwered rescue services}} \cdot \text{population in Sweden}$$

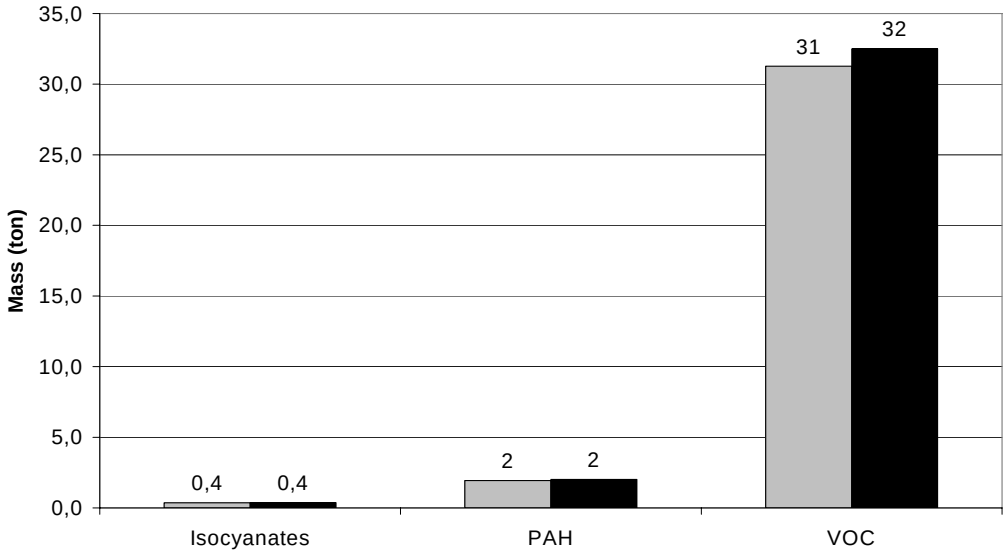


Figure 1 In the diagram the staples shows the total annual emissions from the rescue services fire fighting exercises in Sweden for some common combustion products. The bars represent two different methods used in the estimation of the fuel consumption.

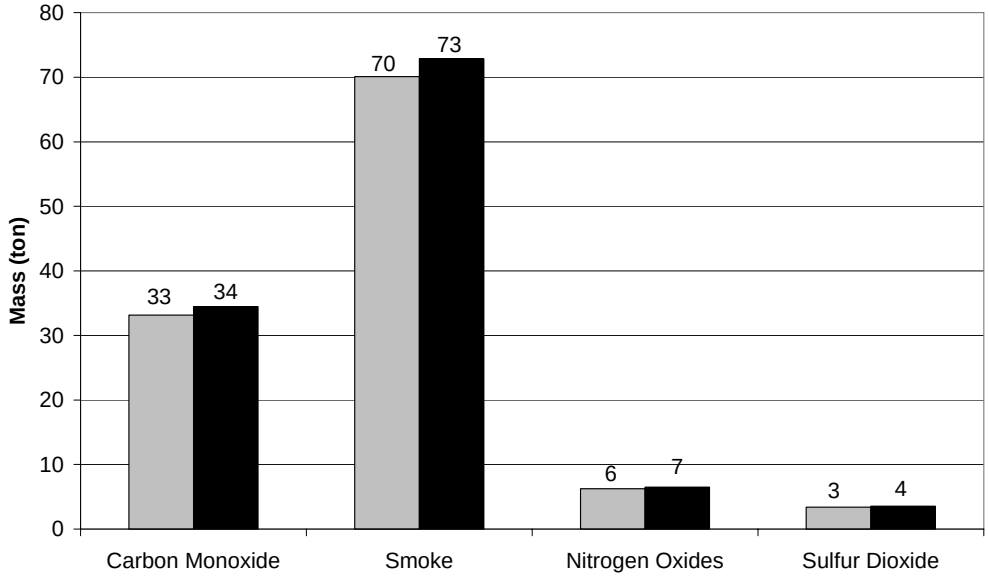


Figure 2. The total annual emissions from the rescue services fire fighting exercises in Sweden for the hazardous compounds isocyanates, PAH and VOC. The bars represent two different methods used in the estimation of the fuel consumption.

The slight differences in the amounts of emissions between the two methods are negligible in comparison with other uncertainties in the survey (questionnaire).

Fire fighting exercises in Sweden emit about 5000 tons of carbon dioxide annually. This amount of carbon dioxide would be emitted if a person flew a plane from Gothenburg to Stockholm and back again about 25 000 times.

The use of particleboards can cause severe health effects. When particleboards are combusted isocyanates are produced. These compounds can, if inhaled, cause harm to the respiratory system, therefore it is important to minimize the use of this kind of fuel.

Conclusions

In a broad perspective no adverse environmental or health effects could be identified. But further studies should be done on the local effects of fire fighting exercises. The emissions from exercises are generally negligible in comparison to emissions from other sources such as traffic, with the exception of particle emissions.

The emissions generated by fire fighting exercises should also be considered as potential health hazards in the working environment. The fire fighting personnel might be exposed to a large amounts of hazardous compounds such as PAH, fine particles and isocyanates.

Probabilistic safety assessment of test intervals at Ringhals 1

Lars Antonsson
Magnus Persson

Abstract

This paper briefly describes a project that evaluates the possibility to perform more effective periodic testing of standby safety systems at Ringhals 1. A quantitative probabilistic safety assessment is performed in order to evaluate the possibility of reducing the total number of tests while keeping the safety level, i.e. the core damage frequency, at a constant level. Drawn conclusions from the quantitative analysis and literature studies lead to conclusions regarding necessary areas of development of the existing model of Ringhals 1 and a proposal of methodology regarding changes of the test intervals prescribed by the TS of Ringhals 1.

Every Swedish nuclear power reactor must have a document called Technical Specifications (TS) that, among other things, describes how often periodic testing should be performed. In order to ensure an acceptable level of risk during operation of the boiling water reactor Ringhals 1 a large number of periodic tests and inspections are carried out. The primary objective of these tests is to verify that the components of standby safety systems are functioning in case of accidents or deviations from normal conditions. The Swedish nuclear regulatory commission (SKI) presumes that optimization of test intervals is possible by the use of probabilistic safety assessment (PSA). Ringhals AB therefore considers that it is interesting to investigate the possibility of using PSA with focus on the periodic tests and test intervals of Ringhals 1 (R1). The objective of the project is to study the requirements of test interval optimization and to give a proposal of a method to make the periodic testing of R1 more effective.

A quantitative analysis is performed in order to answer the following questions:

- What effect has the test intervals on the expected core damage frequency?
- Which test intervals has the biggest impact on the total risk?
- Which test intervals are optimal with respect to safety and benefit?

PSA

PSA is a method to systematically identify, evaluate and rank event sequences that can lead to unwanted consequences (for nuclear power plants mainly core damages and release of radioactivity to the surroundings). The method combines a number of different methods of analysis, i.e. fault tree analysis (FTA), event tree analysis (ETA), failure mode & effect analysis (FMEA), and a set of deterministic data to represent a system and its reactions to deviations, see figure 1.

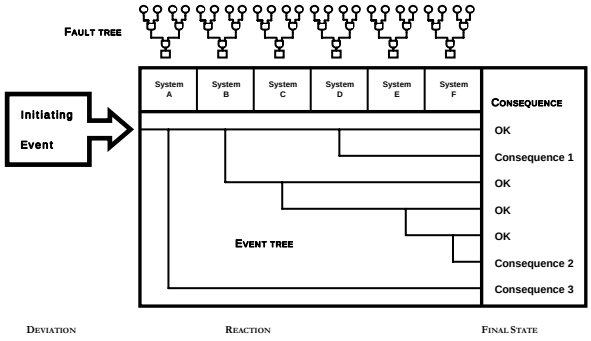


Figure 1

PSA of a NPP can be performed on different levels of analysis, namely PSA Level 1, PSA Level 2 or PSA Level 3. The analysis performed within this project is a level 1 analysis, which means that the core damage frequency is estimated.

To quantify the results, reliability calculations has to be performed. Initiating events are quantified with frequencies from separate analyses and for the fault tree top events probabilities are calculated via MCS analysis. To be able to calculate the probability of the fault tree top event, probabilities for the basic events has to be defined or calculated. The reliability calculations executed in this project are based on the concept of unavailability, i.e. the probability that the system is not functioning at a give time point.

By calculating the total unavailability, QTot, for the fault trees top events in one event sequence and multiply it with the frequency of the initiating event the frequency for respective sequence in the event tree can be calculated.

In order to make probability calculations a mathematical model of Ringhals 1 has been developed. The model consists of fault trees representing critical system elements and event trees representing possible deviations and events that can lead to negative consequences. The model consists of a large number of basic events, gates, fault trees, event sequences and event trees. In spite of its level of detail it should be noticed that the model still is a simplification of the real system and based on a number of deterministic assumptions. The basic events represent failures on component level. Some components availability is dependent on periodic testing. By testing these components their unavailability is reduced and hence the system as a whole gets a lower core damage frequency. By performing periodic testing the core damage frequency is reduced. This is a simplification of a real system/component that can actually get a higher unavailability if tested too frequently. Another simplification in the model is that the unavailability of periodically tested components is divided into one time dependent and one time independent part, implying that the component has a fixed unavailability independent of testing.

The computer programme used to execute the simulations (calculations) is called Riskspectrum PSA Professional. The following types of calculations are performed with the programme:

- Minimal Cutset analysis (MCS)
- Uncertainty analysis
- Importance and sensitivity analysis
- Time dependent analysis.

Method

Literature studies lead to the conclusion that there are no existing methods that can be applied to minimize the total number of tests while keeping the core damage frequency constant, without implementing an additional criterion. Therefore, a method for optimization (or rather improvement) of the test intervals proposed by Sparre, 1999, was chosen. This method was preferred for mainly the following reasons:

- The method is based on the use of the importance measure Risk Decrease Factor (RDF), which is easily calculated using Riskspectrum.
- The majority of the calculations can be performed using mean minimal cut-set analysis, which supposedly leads to shorter calculation times and hence a more time effective procedure.
- The method proposes the criteria that all tests should have the same RDF, which will lead to a reduced number of tests with a constant core damage frequency.

Based on the quantitative analysis the following important conclusions are drawn:

- Many of the tests that have a high importance (high RDF) for the total core damage frequency has relatively short test intervals today (336 or 672 hours), which implies that these tests are tested appropriately.
- There is a possibility to reduce the total number of periodic tests that is performed on R1 without lowering the safety level (i.e. keeping the core damage frequency constant).
- The absolute frequency for the different categories of core damage, and hence their fractional contributions to the total core damage frequency, is affected by changes in test intervals.

Performed sensitivity and uncertainty analyses show that:

- Tests are not equally sensitive to the assumption that the unavailability is separated into one time dependent and one time independent part.
- The deterministic assumptions, that the model is based upon, affect the resulting test intervals of the optimization.

- The results of the original analysis give an indication whether a specific test interval should be lengthened or shortened.

The study shows that further development is needed in certain areas to make PSA on the model of R1 a fully developed and useful tool in optimizing test intervals. These areas mainly include deficiencies in the R1 model and lack of acceptance criterions regarding changes in test intervals. A proposal on methodology for optimization of test intervals based on the model of Sparre, 1999, is presented in the report.

References

Sparre, Erik (1999) *Risk based test interval and maintenance optimisation - Application and uses*, SKI Report 99:55, Swedish Nuclear Regulatory Commission, Stockholm, Sweden

Systematic safety management within eldercare – Implementation of Tryggve at the home for old people of Ekdalagården, Härryda kommun

Josefin Hybring

Abstract

Most people will someday grow old and perhaps need help to manage daily life. Homes for the elderly are a form of care that give people an opportunity to live a life with dignity, provide them with a sense of security and a feeling of community. In order to offer this security that all people are worthy of, it is important to identify risks connected with homes for the elderly and plan for routines in how to handle them.

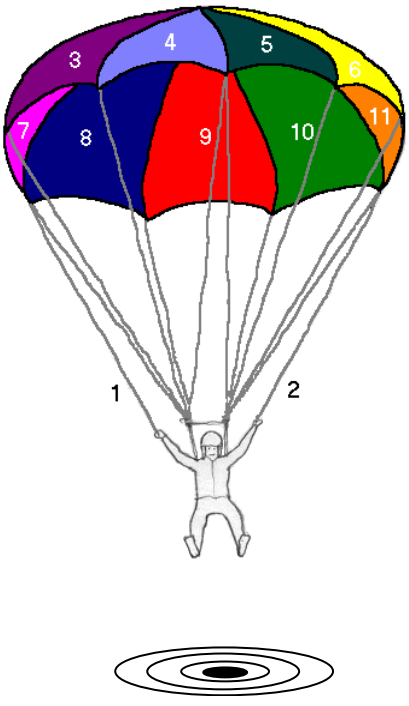
The new law of protection against accidents will come into effect in Sweden on January 1st, 2004. The demand for work involving risks at homes for the elderly will then increase. To make it easier to start with the work of systematic risk management at these homes, a problem solving procedure is presented in a master thesis at the Department of Fire Safety Engineering Lund University, Sweden.

The aim of this report is to survey the risks connected with homes for the elderly, to be able to enhance security and decrease the inherent risks. The goal is to create a tool that will facilitate working with risk management at the homes, and thus increase security in daily life for the residents, personnel and visitors. The starting point of this report is the home for the elderly of Ekdalagården in Härryda kommun.

Everyone is exposed to different kinds of risks every day, voluntarily as well as involuntarily. To work with systematic risk management means to continuously identify risks, prevent them, and in some cases totally eliminate them. Despite a thorough security program, to err is human and that means that accidents will continue to occur. Systematic risk management provides an opportunity to partly control risks as well as the consequences of an undesired incident.

For implementation of systematic risk management at homes for the elderly, the parachute jumper Tryggve has been developed. It symbolizes a human being who is exposed to a risk. The ropes of the parachute symbolize the rules and regulations of an existing organisation and the risks surrounding it. Tryggve has the opportunity to control the jump as long as the parachute is intact. By working with all included parts of Tryggve, opportunities for an enhanced feeling of security for those concerned are created.

1. Description of the organisation and risks
2. Laws and regulations
3. Safety policy
4. Security organisation
5. Information material and educational objective
6. Security rules
7. Security description
8. Control system and follow-up
9. Instruction for control rounds
10. Report and evaluation
11. Documentation



Each part of Tryggve provides significant information, so it is important that *all* sections are included in the systematic safety management plan.

- **Aim** – It is important to be aware of the goal of systematic safety management. Tryggve is able to steer in the right direction whether it is windy or not.
- **Description of the organisation and risks** – Describes the organisation in question and its risks. By making this clear the resource and manpower can be used as effectively as possible. The description will be the basis for continued safety management.
- **Laws and regulations** – To be able to uphold good security and a safe environment, it is important to be aware of the laws and regulations that concern the organisation.
- **Safety policy** – A safety policy shows that within the organisation safety management dominates. It describes the goals of the work and makes the idea of high risk thinking within the organisation clear. It is a support mechanism that makes it easier to work with systematic safety management so the laws and regulations will be upheld, plus it also shows the organisation's own ambition.
- **Security organisation** – Through continued and systematic work, its obligation is to minimize the risks within the organisation and ensure a high level of safety. By means of a security organisation the sense of security is guaranteed.
- **Informational material and educational objective** – To maintain a high level of security, it is important that the people concerned get the necessary education. In the event of an accident it may be the staff's actions that make the difference between life and death.
- **Security rules** – By introducing security rules the consciousness of the risks will increase and the risk for an accident will decrease.
- **Security description** – Gives a general overview of the security equipment and forms the basis of the control rounds.
- **Control system and follow up** – Through systematic prevention, the identified risks and security equipment can be controlled and therefore maintain a high level of security. If the defects and faults that are found during the control rounds are not taken care of and followed up, the work is useless and the whole system will fail.
- **Instruction for control rounds** – Through supervision, one is able to control the working of a component correctly. It also facilitates the control work. The procedure will be the same even if different people perform it.
- **Report and evaluation** – Reporting accidents and near-accidents is important to see if the safety management has a desirable effect. With a well designed reporting system, improvements or deteriorations can be discovered and the work can be evaluated.
- **Documentation** – To ensure that safety management is carried on within the organisation, documentation is important.

The model of Tryggve provides a foundation to work from and it offers each organisation an opportunity to design individually adjusted risk management plans. Tryggve signifies that the organisation continuously works to improve itself and to provide a secure environment. It also promotes the importance of responsibility and security.

It is important to emphasize that Tryggve only creates conditions to work with security and that the result depends on the commitment from the organisation. The material that is produced in connection with Tryggve must be constantly improved, giving those concerned a chance to participate and to be influential. Together the organisation must work for guaranteeing the sense of security offered at homes for the elderly.

References

/1/ Akselsson R., *Människa, teknik, organisation och riskhantering,* Lund University, Lund, 2003

/2/ Hybring J., *Systematisk säkerhetsarbete inom äldreomsorgen – Applicering på äldreboendet Ekdalagården, Härryda kommun,* Report 5131, Department of Fire Safety Engineering, Lund University, 2003 (Swedish)

/3/ *Intern brandskyddskontroll*, Svenska brandförsvarsföreningen, 1995

Risk identification in underground stations – a suggestion for working method

Erik Midholm
Magnus Widlind

Abstract

Can the risk identification and risk analysis in Swedish underground stations be improved and more effective? This project has produced a general model, which is supposed to be used as a tool during risk identification in underground stations. With the model it will be possible to identify the risk source, determine the consequences that can occur in association with the risk source and get suggestions of preventing measures to reduce or prevent the risk.

This project is a master thesis, which has an overall aim to improve the personal safety in Swedish underground stations. Today the most underground stations in Sweden belong to the system of Stockholm Metro, but within time there will be at least two more systems with trains underground. The project has been carried out on commission of Brandskyddslaget AB and in co-operation with Stockholm Transport (SL), Connex AB, Stockholm Fire Department, Banverket, Swedish Rescue Services Agency and Lund Institute of Technology (LTH).

Why is it required to improve the risk identification in Swedish underground stations?

There has not yet occurred any serious accidents in any Swedish underground station, but the last few years' serious accidents in tunnels and underground stations around the world shows the importance of improved safety. Even if there often are differences, both organized and material, between Swedish and foreign underground systems, there are a lot of risk sources, which has led to accidents in other countries, that can be identified in e.g. Stockholm Metro.

One of the most important requirements in organizations is to create awareness of the events that can lead to non-wanted consequences. If the organization lacks this awareness it is not possible to improve the personal safety. For this reason it is important to create a *good* safety culture within the organization. A good safety culture is distinguished by three head points:

- awareness
- commitment
- motivation

With improved risk identification the first of these three points can be achieved.

To create better conditions during an organization's risk management, the risk management process ought to start with a thorough risk identification and risk analysis inside the different systems of the organization. This will make an overall view of the risks that the organization has to handle and it will then be easier to determine whether it is possible to completely reduce or just prevent the risks.

The model for risk identification and risk analysis in underground stations.

The aim with the project is to make a model which could be used during risk identification in underground stations. The model will in a foreseeable way structure the risk sources that can affect personal safety. The user of the model will have the possibility to analyze and rank the identified risks through subjective judgements.

The model for risk identification and risk analysis in underground stations is based on the result from a risk identification made in Sweden's biggest and most complex underground station, T-centralen in Stockholm Metro. The working method being used in this risk identification concluded usage of risk analysis methods (Preliminary Hazard Analysis and Anticipatory Failure Determination in groups) and a great amount of interviews and visits. Besides studies of T-centralen complementing visits and interviews has been made in Lisebergsstationen, Gothenburg and in Canary Wharf (The Jubilee Line Station) in London Underground.

The *model for risk identification and risk analysis in underground stations* is divided into four categories: fire risks, technical risks, human related risks and evacuation risks. During this project's risk identification risks related to organization also were identified, but the structure of the model didn't suit this category of risks.

Risks in underground stations.

As mentioned above the risk identification made in T-centralen were divided into four different kinds of risk sources. In every category many risk sources were identified. Some of the risk sources even occurred in more than one category.

Fire risks.
As an example of the fire risks that were identified in T-centralen, trash fires will be described more thorough. Trash fires are the most frequent fire risk in Stockholm Metro and a large amount of the trash, which is burning, contains free news papers, such as Metro and Stockholm City. Every day about 11.000 free news papers (almost 900 kg) are distributed in T-centralen. This leads to an increased fire load and an increased probability of trash fires.

However, it is important to remember that a burning news paper lying on the platform is not very dangerous. It is the possibility of the trash fire to spread to e.g. cables that is the danger since a cable fire can lead to catastrophic consequences.

Technical risks.
One thing noticed during the identification of technical risks is that these are often events that don't affect the personal safety very much unless they are combined with other factors, e.g. an evacuation.

The absolutely most frequent technical fault in T-centralen is non-functioning escalators. During the last seven years escalators were out of function over 1100 times. The escalators in T-centralen are long and it is not very easy to walk up a non-moving escalator since the steps often are higher than in usual stairs.

One of many faults that can occur in escalators is that the breaks are active even though the escalator is moving. This leads to production of heat and smoke. If the breaks are not mended in time, the heat production can lead to ignition of transmission oil and filth.

Human related risks.
Every year about 30 people dies in the underground system. Many of these deaths depend on persons who chose to commit suicide. The high velocities of the subway trains makes people believe that they are jumping to an almost certain death when they are jumping down on the tracks in front of the train. In T-centralen, about one suicide attempt occurs every year.

There are also other reasons why people get run over. They might, for example, be pushed down on to the tracks if it is very crowded on the platform.

Evacuation risks.
During identification of risk sources belonging to this risk category, the conditions in the underground station were different than for the other categories. The definition of an evacuation risk in this project is: *An event that could complicate a necessary evacuation during an emergency (such as a fire or smoke development).*

As mentioned above non-functioning escalators are a very common fault in T-centralen. During an evacuation this could increase the time to evacuate since the escalators often are long and steep. One event that could be even worse is if the escalator is completely blocked. A person falling or a pram in the escalator can be enough to complicate the evacuation.

Risks related to organization.
The risks related to organization are not presented in *the model for risk identification and risk analysis in underground stations*. Instead these risks, which might be better described as lack of e.g. routines and rules, are presented in the master thesis *Risk identification in underground stations – a suggestion for working method.*

An example of a risk related to organization is lack of communication. Today all communication in Stockholm Metro is one-way, which means that as one person speaks in the radio system no other can speak.

It is also possible for the communication to go a couple of different directions to reach it's goal. Figure 1 presents the different directions the communication can go from that as a fire occurs

until the travellers in the station become aware of the evacuation.

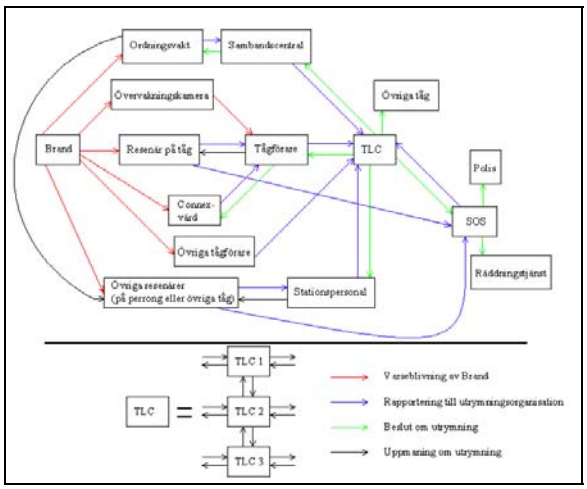


Figure 1. Presentation over directions of communication during a fire in a train in T-centralen (figure is in Swedish).

The great amount of different directions makes it hard for the staff to find the shortest and most effective way for the communication to go. This can lead to an increased evacuation time.

Risk analysis in T-centralen.

When the *model for risk identification and risk analysis in underground stations* was finished it was used during a risk analysis in T-centralen. Subjective judgements along with studies of statistics and expert judgements were made to analyse the risks that had been identified. During the risk analysis risk criterion where used to make it easier to estimate and rank the risks.

Criterion for probability:

1. Not likely	< 1 time per 10 years.
2.	1 time per 1- 10 year.
3. Likely	1 time per month - 1 year.
4.	1 time per week - month.
5. Very likely	>1 time a week.

Criterion for consequences:

1. Small	Temporary discomfort.
2. Mild	1 or two mildly injured and/or lasting discomfort.
3. Large	1 or two badly injured and/or great lasting discomfort.
4. Great	1 or two dead and/or several badly injured.
5. Catastrophy	Several dead and/or > 10 badly injured.

The risk analysis in T-centralen showed that the greatest risks in that underground station are:

- Great amounts of trash, grease and filth (especially in escalators and in unlocked garbage rooms).
- Unauthorized tread on tracks.
- Drunken or drugged travellers.
- Crowded trains and platforms in case of an evacuation.
- Travellers with a physical handicap or a pram in case of an evacuation.
- Non-moving escalator in case of an evacuation.

In addition to the risks above, an amount of other risks should be observed, either because of their great probability or consequence. Below a couple of those risks are presented:

- Jumping in front of trains.
- Falling in escalators.
- Sabotage.
- High fire load, i.e. advertising, trash and combustible isolation material.
- One-way communication.
- Only one way out.
- Safety managers with economical responsibility.

The ideal underground station.

It is impossible to completely defend oneself from every risk that can occur in an underground station. On the other hand it is often possible to reduce the size of the risk (either by reducing the probability for the accident to happen or by reducing the consequence if the accident happens). A suggestion concerning the structure of the preventing measures, both material and organized, in an underground station, called *the ideal underground* station has been developed. *The ideal underground station* ought to prevent a great amount of the risks, that are possible to occur in an underground station.
The ideal underground station includes measures as i.e. risk management, systematic fire prevention, education of the staff, rules and routines, report systems, camera surveillance, glass walls between platform and tracks.

The ideal underground station also gives a suggestion of a new form of communication net. First of all every radio system has to have a two way communication function. This will reduce the probability of misunderstanding and give a reduction of alarm time.

The different ways the communication can go should also be reduced to make it easier for the staff and the travellers to alert everybody that the station needs to be evacuated. Figure 2 shows the suggestion for different directions that the staff and the travellers should be able to use in case of a fire in a train in T-centralen.

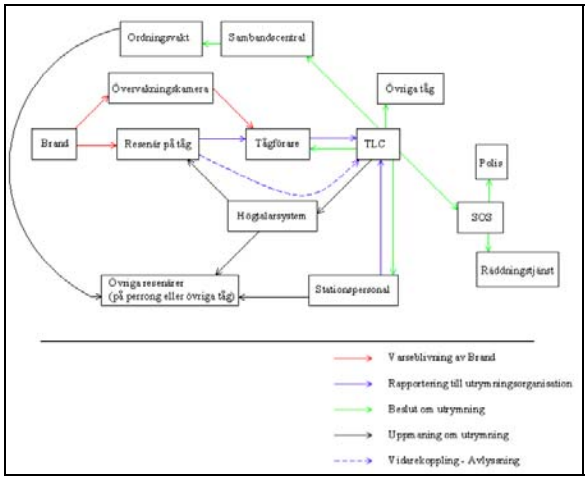


Figure 2. Suggestion for directions of communication during a fire in a train in T-centralen (figure is in Swedish).

Discussion and conclusions.

In the initial stage of the project several parts asked for a quantitative risk analysis (QRA) in T-centralen. One of the first conclusions made in this project was that it is necessary to make a risk identification before the organization even thinks of producing a QRA. Further it is necessary to have a great statistical basis available if the result of the QRA shall be reliable. That's why an organization has to have a fully developed report system so that the statistic is reliable.

Another conclusion made is that it is impossible to be sure that every risk is identified, no matter how big your risk identification process is. What you can do is to use different methods to improve the result of the identification. Using only one method will not be enough.

Finally the authors of this project think that *the model for risk identification and risk analysis in underground station* can, together with reliable statistics become a base for a quantitative risk analysis.

Risk management in health care activities – a basis for improvement

Tobias Jansson
Henrik Nilsson

Abstract

How can the Risk Management for health care activities within Västra Götalandsregionen be improved? This project will hopefully answer the question by compiling a framework for Risk Management in health care activities and by comparing that framework with the present situation at three objects in Västra Götalandsregionen. Recommended measures are given for the analyzed objects as well for Västra Götalandsregionen as a whole. The framework consist of the three elements Control regarding risk management, Risk management according to IEC and Safety culture. The content and signification for these elements are discussed.

This project is a master thesis, which has the overall aim to improve the risk management for health care activities within Västra Götalandsregionen. The objective is to develop a framework for Risk Management and to give proposals of improvement regarding risk management at the studied objects as well as for all health care activities within Västra Götalandsregionen. The project has been carried out on commission of Västra Götalandsregionen and in co-operation with Willis AB and Lunds tekniska högskola. Willis AB is Västra Götalandsregionens insurance broker. Due to the size and configuration of the organization the analyzing part of the project has been delimit to a hospital, a casualty department and a health centre.

Risk Management in Health care activities

Risk management in health care activities is not, in general, developed to the same extension as in the nuclear field or chemical industries. Traditionally the work with safety issues at hospitals has concerned the technical supply systems and vulnerability of building constructions. It has also been concentrated to events like war and other extreme events. The SSIK (Sjukvårdens säkerhet i kris och krig) group, has published literature which includes advices regarding construction, maintenance and monitoring of technical supply systems. Nevertheless, the legislation demands risk management in health care facilities to contain more than those parts.

A tragic event that points out a need for improvement of risk management within health care activities is the fire at the psychiatric clinic in Växjö, with two casualties. The remarking thing with this event is that there was a sufficient safety policy demanding good risk management to be performed. But a lot of lacks regarding the safety related to this event makes it obvious that good risk management was not performed. Why? The safety policy was sufficient and was clearly demanding good risk management to be performed. The problem is that it is not obvious what good risk management is. How are the employees going to be able to perform good risk management if they do not know what it is? There must be some way to enable the way from demands of good risk management to action. We can clearly see a need for guidelines describing good risk management.

Hence it is not sufficient to work in the traditional way when dealing with risks in health care activities, some questions at issue are therefore to be addressed. The overall question at issue is *how can the Risk Management for health care activities within Västra Götalandsregionen be improved?* To be able to answer this, the question is divided into a number of minor questions.

What characterizes a sufficient risk management in health care activities? This question will hopefully be answered by compiling important element in a framework for risk management describing good risk management for health care activities.

How is the risk management at the chosen objects? To answer this question a survey of the present situation is carried out.

What needs to be improved? With respect to the developed framework, conclusions and recommendations of measures that improve the risk management are made. Both the conclusions and the recommendations are made with respect for the chosen objects as well as for Västra Götalandsregionen as a whole.

Risk management framework for health care activities

To be able to answer one of the questions at issue in this project a framework for risk management, based on literature studies, was developed. The framework was made to describe good risk management for the health care activity within Västra Götalandsregionen. The framework consists of the parts that are considered important for risk management within the organisation. All the parts are structured and divided into the elements *Control regarding risk management*, *Risk management according to IEC* and *Safety culture*. It is activities related to these elements that are considered as risk management.

Control regarding risk management consists of different authorities within the organisation that are related to risk management and the way the management directs and controls the organisation with regard to risk.

R*isk management according to IEC* means the handling of risks by performing risk analysis, risk evaluations and risk reduction/control.

The inherent *safety culture* within the organisation control if the employees take unnecessary risks, do not learn from incidents or do not know about the risks related to the activity.

The elements describing risk management in the framework are shown in figure 1. These elements are interacting and activities within one element can often be direct measures of activities related to another element.

Figure 1, The definition of risk management which is used in the framework. It is obvious that the elements are interacting.

For example, risk management according to IEC can lead to necessary changes in the control regarding risk management to be able to reduce a special type of risk.

Figure 2 summarizes the developed framework for risk management. Each column consists of important components of the actual element. Some of the components of control regarding risk management are for example *reporting system*, *risk management system* and *means of control and incentives*. These components aim to control the organization regarding its risks. The column risk management according to IEC includes *fazes* of risk management, different *types of methods*, *choosing methods* and *demands on risk analyses*. The last element – safety culture – consists of nine aspects that are important for the safety culture within an organization. These factors are for example *learning*, *reporting* and *attitudes regarding safety*.

Survey of present situation

On the basis of the theory, described in the framework for risk management, a survey of the present situation at the three objects was carried out. This survey is a foundation for the assessments made, which results in proposals of concrete measures to improve the risk management at the studied objects. The survey comprises the present situation concerning control regarding risk management, risk management according to IEC, the inherent safety culture and a comprehensive compilation of the risks that the health care activity at the three chosen objects is exposed to. The present situation concerning control regarding risk management and the present situation concerning risk management according to IEC was surveyed by interviews and visits to the objects. To get an overview, control documents concerning risk management were also studied. The inherent safety culture was also surveyed by interviews and, as complement to this a, questionnaire survey was used. Literature studies, AFD-2 (Anticipatory Failure Determination), HHM (Holographic Hierarchical Modelling) were used to get a comprehensive compilation of the risks that the health care activity at three objects is exposed to.

All the persons that were interviewed were chosen with respect to their relation to risk management. They were either employees within the safety organisation or employees having a chef position close to the lowest level within the

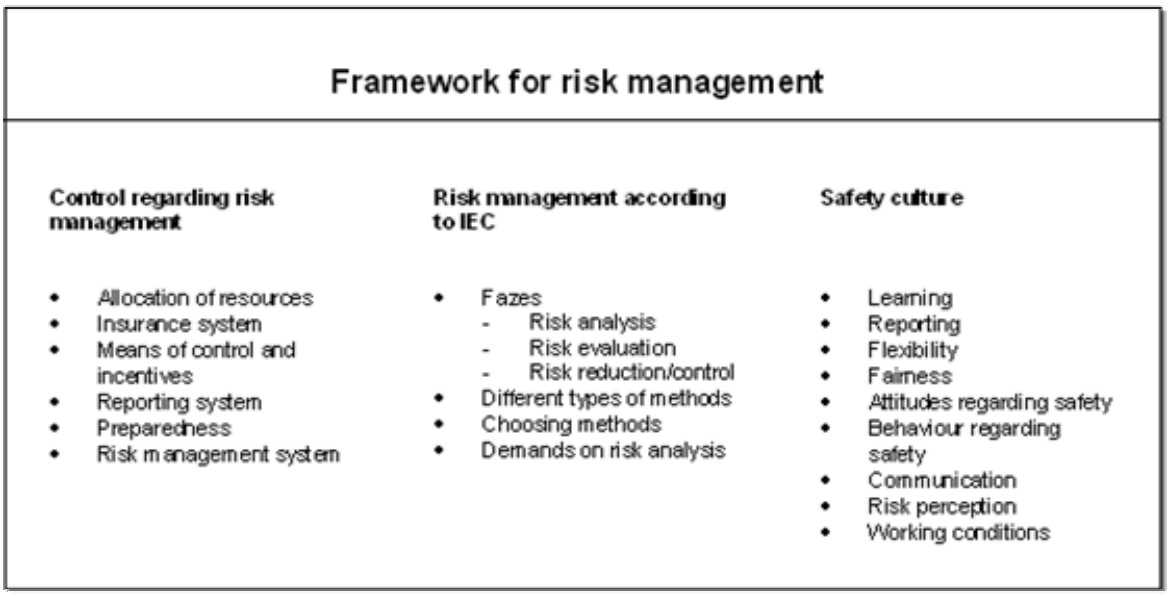


Figure 2 – The framework for risk management.

organisation. This approach was chosen because it gives an indication of the risk management at higher levels within the organisation. The reason for this is that commitment from the management regarding risk management is often reflected on to the employee's behaviour. Policies and strategies will also give an indication of the management commitments regarding risk management.

The interviews were performed at the interviewee's normal workplace. All the interviews were structured and planed ahead, although, the interview looked more like a conversation or discussion than a formal interview. The purpose for this was that it would generate a more relaxed environment. Every interview was carried out by two interviewers taking notes. As a complement recording equipment was used.

Considering the performance of the interviews the result from it is considered to be good. The result should probably be the same if other people, having the same background, were to carry out similar interviews.

The safety culture has been examined by interviews regarding risk management as well as by a questionnaire. The questionnaire comprises persons that have participated in the interviews and a number of employee's from the wards of the interviewed persons. The selection in the interviews has been done to represent the constitution of the employees. 16 persons have been interviewed altogether. The questionnaire is based on the nine aspects, which are a prerequisite for a sufficient safety culture. The aim of the questionnaire is not to give a modulated image of the safety culture, but to receive an indication of what the staff view of safety and its aspects are like.

To get an idea of the risk exposure on the objects, literature within the field of work has been studied. A broad analysis on a typical hospital was conducted on the basis of the literature studies. On the basis of the risks that were found an image of the risk exposure was made with by Hierarchical Holographic Modelling (HHM). To complete the image of the risk exposure, risk identification was conducted with a simplified version of a method called Anticipatory Failure Determination – Failure Prevention (AFD-2).

Seven risk identifications were carried out in groups of 3-5 persons, where the authors were the head of the identification.

The survey of the present situation has been reviewed by the safety council of Västra Götalandsregionen to make sure that the quality of the information received is good. This has made it possible to reduce inaccurate information and to improve bad formulations.

Measures for improvement

Some of the recommendations regarding all health care activities within Västra Götalandsregionen are for example, that straight demands are made between Västfastigheter and the health care activities and that a risk management system is developed. It is also recommended that the

risk exposure is identified for all hospitals within Västra Götalandsregionen and that a common computerized risk reporting system is introduced. Checklists should be developed for simple risk analysis on ward level. Further recommendations are education in basic risk management for the risk management organization as well as for new employees. One of our conclusions is that the risk management on the health centre is insufficient, and it is therefore recommended that Västra Götalandsregionen investigate if this is the case for other health centres. If so, measures should be taken immediately.

Conclusions

It is interesting to make an assessment of the level of the risk management at the studied objects, by comparison with other health care activities as well as other fields. Visits to two other hospitals were initially conducted. Although no thorough analysis was performed, the risk management at the studied objects was assessed to have a greater level than at one of the two visited hospitals. It was not possible to asses whether the level of risk the management at the studied objects where higher then on the other visited hospital.

The most important conclusion in this project is how VGR should conduct sufficient risk management in the future. For start, the organization should implement the recommended measures. This is not enough though, and should therefore be complemented with following:

- To succeed when risk managing at health care activities a comprehensive approach must be taken. This can be done by applying the developed framework on the actual organization. I must be noted that the framework does not do risk management by itself. For instance, the organization must have the ability to understand the content of the framework and they must be open to self criticism.
- The next step on the way to a sufficient risk management process is to implement a risk management system. This step will make it more clearly for the individuals within the organization how the objectives of the safety policy are achieved with actual actions and measures.
- The organization should focus on working centrally to the widest possible extension. The forum that the safety council constitute is a good starting point, since it leads to effectiveness and sharing experiences.

The developed framework for risk management that has been developed in this project is aimed for health care activities. It is possible though, to apply the framework on other fields as well as long as it is noticed the framework is characterized by the studied objects and that this may affect the result of usage.

Some problems occurred when risk management was to be defined. The definition that has been developed by IEC does not suit to describe risk management for health care activities in a sufficient way, why the newer wider definition by ISO/IEC was chosen. The name of the element risk management according to IEC is not satisfactory, but had to be chosen due to lack of an appropriate name.

Modelling Crowd Evacuation from Road and Train Tunnels – Data and design for faster evacuations

Anders Norén
Joel Winér

Abstract

Focusing on tunnel safety from a risk management perspective the purpose of this report is to analyse the factors that affect the efficiency of crowd evacuations from road and train tunnels. These factors are analysed from two perspectives; first evacuation efficiency from the tunnel users' perspective is studied, then the tunnel control room is analysed.The report is the master's thesis of the Risk Management and Safety Engineering Programme of the Lund Institute of Technology. The report is originally written as a part of the UPTUN-project, a project aiming at cost-effective, sustainable and innovative upgrading methods for fire safety in existing tunnels. The UPTUN-project is being carried out with financial support of the European Commission under the Fifth Framework Programme, Competitive and Sustainable Growth Programme.

Introduction

Accidents in road or train tunnels are primarily a danger to the people directly involved in the accident. But if a fire breaks outs, these accidents become dangerous also to other people who happen to be around in the tunnel. The fires caused by accidents in the Tauern and Mont Blanc tunnels in 1999 are tragic examples of this (see Voetzel, A. 2002).

Means to prevent accidents are: technical improvements such as one-directional tunnel tubes and behavioural improvements such as alerting drivers earlier. This is a neverending process aiming at safer tunnels, but not all accidents can be prevented. Therefore, measures are also required that mitigate the consequences of accidents. Technical measures are e.g. fire extinguishers in the tunnel and escape ways enabling people to leave the disaster tube and walk to safety.

However, the most successful way to achieve safer tunnels in the long run is to keep a risk management perspective including all factors that affect the safety of the tunnel users. This includes a struggle for improvements of the technical and behavioural means mentioned above but also a struggle to improve the role of the control room during accidents. These are all to be seen in a context as they influence each other.

Purpose

Focusing on tunnel safety from a risk management perspective the purpose of this report is to analyse the factors that affect the efficiency of crowd evacuations from road and train tunnels. These factors are analysed from two perspectives; first evacuation efficiency from the tunnel users' perspective is studied, then the role of the tunnel control room is analysed separately.

The purpose of the first part of the study is to quantify the time needed for tunnel evacuation. In the early moments of the accident, the fire will be small and the opportunity for escape is relatively good. Later, the fire may have grown and smoke may have filled the tunnel. It is important to know how much time is needed for evacuation, and to compare this to the time available for evacuation. In principle, the time for evacuation should be as short as possible.

The purpose of the study of the control room is to see how different ways to organise the work correspond to the tasks of the control room. As the actions taken in the control room directly affect the course of events inside the tunnel it is important to study how the staff should be organised to be as efficient as possible.

Theory and tests

The time needed for evacuation is not equal to the time needed to walk to the emergency exits. Accidents come by surprise and are unplanned, and the victims of a disaster should abandon their original plans completely. That

takes time. Hence, adequate models of evacuation should have a stage called "awareness time" or "reaction time" before anyone starts to walk to the emergency exit (see e.g. Passenier & Van Delft, 1995). In the current report we use a third, optional, stage that stands between these two stages: *hesitation*. All three stages are based on observable behaviour.

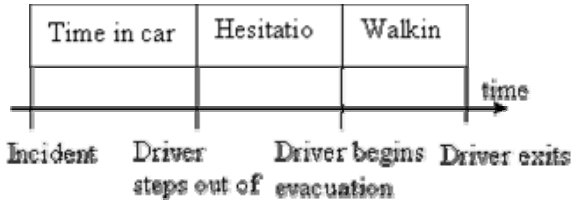


Figure 1, The three-stage model used for quantifying the evacuation process.

The report presents the three-stage model. Based on observations in road and rail tunnels, the model finds its quantification. This quantification addresses both the transition between successive stages as well as the distribution of time required per stage. For road tunnels, a complete three-stage model of evacuation time is achieved. For rail tunnels, the output is a partial model because only observations on planned egress were available. In the report an example of how the model can be applied is provided and the possibilities for computer modelling are discussed.

The observations for the road tunnel case were made during nine tests where drivers entered a tunnel in a row, following a heavy goods vehicle (HGV). In the middle of the tunnel smoke started to develop from the HGV that soon came to a halt. Video cameras recorded what happened in the tunnel and this was analysed at a later stage.

Figure 2. One of the nine tests that were made in the Benelux tunnel in the Netherlands to collect data on road tunnel evacuation.

The duration of the crowd evacuation is found to depend on the efficiency of the control room and when confirmative information about the accident can be provided to the people in danger in the tunnel. The efficiency of the control room is to a great extent a question of organisation.

The control rooms can be organised in two basically different ways; the organisation can be designed according to incident-specific or universal decision making. The incident-specific approach provides a high theoretical maximum of success, even if the likelihood is low to achieve the maximum. The universal approach on the other hand does not allow as many possibilities for human fallibility but results in a lower expected theoretical maximum of success in general.

The control rooms of the Ij- and Piet Hein tunnel in the Netherlands and the Öresund link tunnel were visited and analysed according to the incident-specific and universal decision making approaches.

Figure 3. The control of the Ij- and Piet Hein tunnel was taken as an example of the incident-specific approach

Figure 4, The control room of the Öresund link was chosen as an example of the universal approach.

Conclusions and recommendations

In the report conclusions are presented about factors of great importance for the evacuation efficiency. These conclusions are based on the results of several evacuation tests and thorough analyses. Also, recommendations are made about how to fasten the evacuation process.

The importance of information that confirms that the situation is dangerous given at an early stage is perhaps the most important factor. Information given at an early stage helps people make the decision to evacuate.

However, all single factors that are likely to affect the evacuation must be considered. It is the sum of all impressions compared to earlier experience that determines the action taken by any individual, and all these input variables must be put in a context. This is what risk management is all about – considering the effect of all input variables to plan for an optimal output.

References

Passenier, P.O. & van Delft, J.H. (1995). The human-machine interface. Soesterberg (NL): TNO Human Factors.

Voetzel, A. (2002). Compared analysis of the Mont Blanc Tunnel and the Tauern Tunnel fires. PIARC WG6.

Risk management in humanitarian relief operations – Decision making and risk management under complex and highly dynamic circumstances

Tobias Ekberg
Christoffer Tranström

Abstract

The result of this project is an activity suited model for risk management. The objective is to constitute a framework to the Swedish Rescue Services Agency (SRSA) as how to carry on risk management, well suited to its purpose of managing staff safety and security in humanitarian relief operations. The model which we have named the *Three-Two-One model* is based upon conventional risk management theory, as well as the descriptive branch of decision theory. Further more the model is based on a qualitative analysis concerning the composite of problems regarding decision making and risk management within this field of activity.

Introduction

The deteriorated safety and security for humanitarian relief workers is more often emphasized as a serious problem. An example is the attack on the UN office in Baghdad August 19th 2003, were 22 people died and over 150 were injured (Ahtisaari, 2003). Humanitarian relief work is characterised by circumstances of rapid changes and in many aspects high stakes. The threat for the safety and security of humanitarian workers is vast and complex, and may in addition to violence comprise of sickness and strikes of nature for example. Under these circumstances it is problematical to manage i.e. to identify, analyse, evaluate and reduce the risk exposed to personnel.

Appliance of conventional risk management will be limited under such complex and highly dynamic circumstances. The conventional systematic in risk management should for this reason not be rejected, as it is based on many years of research and experience. If anything, it is a performance objective to try aiming at. The problem in question is about producing an activity suited model for risk management, applicable within an organisation performing activities under complex and highly dynamic circumstances.

Analysis

Through a qualitative analysis of the activities and problems in question, a number of significant circumstances, from a risk management perspective, are identified and characterised. These complex and highly dynamic circumstances then lead to a complex of problems, concerning the possibility of carry on efficient risk management. In order to facilitate the description of these problems they are divided into four main sets, which are shown in figure 1 below. Out of these four sets, attaining adequate and shared *situation awareness* stands out as the most significant, in order to carry on efficient risk management under complex and highly dynamic circumstances.

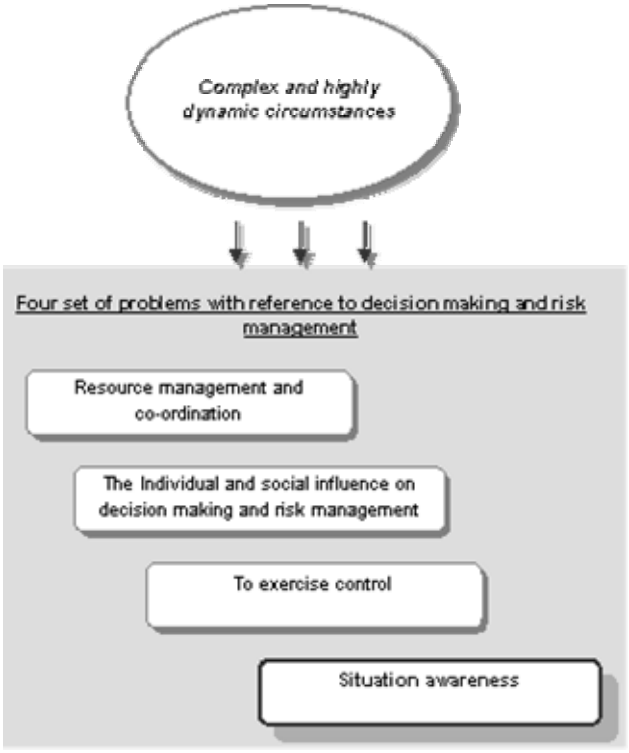


Figure 1: Shows four set of problems which have been identified and coupled to the possibility of well suited decision making and risk management, concerning staff safety and security in humanitarian relief operations.

The analysis of the four set of problems shown in figure 1 above leads to a number of conclusions:

- In order to increase the possibilities of well suited risk management, two main fronts of effect appear to be of great importance. The first one is to *optimize the individual prerequisites* to risk control. This incorporates optimizing the individuals' capability to identify, analyse, interpret, evaluate, communicate and reduce risk. The second front of effect is to *optimize information management* within the organisation. This could be expressed as to optimize the systems, processes, methods and tools which the individual and the organisation uses in order to control operations regarding risk.

- In order to control risk regarding staff safety and security and at the same time be able to control the timeframe and the mental resources necessary to reach this objective, *risk management should be distributed between different levels within the organisation.*

- Safety and security can not only be managed through reactive measures under these complex and highly dynamic circumstances. Instead the objective should be towards a course of *proactive risk management*. This incorporates continuous and active supervision and adjustment, to make sure the limits of safe activity are not overstepped. Crucial is to counteract the forces that drive operations towards the limits of unsafe activity.

These conclusions lead to the formulation of a strategy for risk management:

Risk management with the objective to control staff safety and security in humanitarian relief operations should be directed towards proactive risk management with focus on optimizing the individual prerequisites for personnel to control risk and optimizing information management within the organisation. The risk management within the organisation should be distributed and adapted to different levels in order to avoid negative effect, from the complex and highly dynamic circumstances, on the prerequisites for risk management.

Figure 2: The formulation of a strategy for risk management.

An activity suited model for risk management

With the purpose of being able to, in practice, carry on risk management in compliance with the formulated strategy, a model which we have named the *Three-Two-One-model* should be put into practice. The model structure is based on *three functional levels*, *two processes for risk management*, which all together constitutes *one system for risk management*.

Figure 3: Shows the structure of the Three-Two-One-model, with three functional levels, two processes of risk management which altogether constitutes one system for risk management.

In the main process risk management is carried on with an overall activity perspective, while the main objective in the operational process is to manage risk in a specific operation. However both processes incorporate activities as risk analysis, risk evaluation and risk reduction i.e. activities often associated with conventional risk management. The purpose of this well recognised working process is to elucidate *what might happen*, *how likely is it to happen*, *possible consequences* and *what measures to take to obtain risk control*. In figure 4 below these activities are shown arranged in a way which is normally referred to as the box model, adjusted to suit the activity at focus (Davidsson, G. m.fl. 2003).

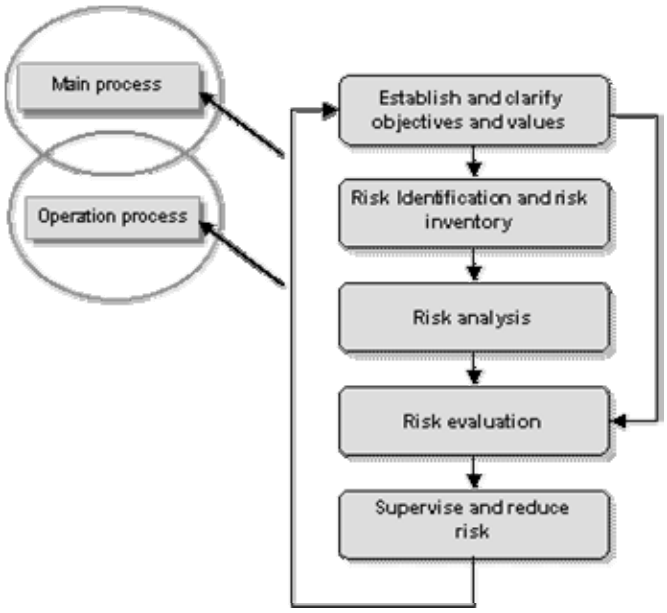


Figure 4: Shows the working process essential for efficient risk management in both main- and operation process.

A description of decision making in a real world dynamic context leads to a number of essential conclusions. In a real world dynamic context, decision making, is to a large extent based on *knowledge*, *experience*, *goals* and *values* (Klein, 1993). The correctness in decision making is a consequence of how these domains are used to create the situation awareness which decision is based on. The overall purpose with the Three-Two-One model is to structure the tasks of risk management in a way that results in thrift of time, mental and information resources and also the optimizing of contents and use of those domains decision making in a real world context are based on.

The model and its practical appliance rely on three essential elements:

- An *information bank* with two main objectives: As a basis for training of staff i.e. to effect and increase the staff individual prerequisites of managing risk. And, to be used and constitute a basis for the operation process. This leads to the access and existence of information in the event of an operation, which otherwise would have be difficult and outmost resource-demanding to attain.

- *Training.* Equipping staff with knowledge, clear objectives and values, creates the right prerequisites to obtain situation awareness, which in turn is the basis for efficient decision making under complex and highly dynamic circumstances.

- *Organisational management of safety and security*. The function of the model demands an active management within each of three levels. The responsibility for the organisation's risk management should lie at department management level. At the same time there should be personnel at the level of the operational co-operation and support, working active with safety and security issues, as well as advisors to both department management and field level.

Final comments

Managing risk and in this case safety and security, is not only about using bullet-proof vests, state of the art communication equipment or taking vaccination against diseases. It is also and to a larger extent a question about organisational *commitment*, *responsibility*, *understanding* and *standpoints*. Moreover comes naturally a personal responsibility amongst staff, which still has to be given the right prerequisites, in order to exercise this responsibility in an adequate way. What should be pointed out is that the function of the organisation risk management is important to maintain even under periods when the demand for risk management is not as evident. For the SRSA this could for instance concern longer periods of operations in non violent areas. An important conclusion that can be drawn based on the work of this project is that the prerequisites for a, to its purpose, well suited risk management in large extent could and *should* be created through organisational measures.

Reference

Ahtisaari M. (2003) *Report of The Independent Panel on the Safety and Security of UN Personnel in Iraq*. Report of the Secretary-General. UN, General Assembly.

Davidsson, G. m.fl. (2003). *Handbok för riskanalys*. Räddningsverket. Karlstad

Klein, G. A. m.fl. (1993) *Decision Making in Action: Models and Methods,* Ablex Publishing corporation, Norwood.

Safety management in the municipality of Gothenburg – analysis of the current situation and a model proposal

Louise Abrahamsson
Lisa Åkesson

Abstract

Swedish municipalities today have big problems with increasing damage costs together with difficulties to get good insurance solutions. Therefore the purpose of the report is to give a proposal on a model for municipal safety management in Gothenburg. This has been made by studying statistics and by doing interviews concerning safety culture in different municipal activities. The most essential part in a model for safety management is a clear safety organisation where everyone involved knows his or her tasks and responsibilities. Another important issue is how to make a risk analysis in a municipal activity.

Introduction

Municipalities in Sweden today have big problems to find good insurance solutions for their properties. During the last couple of years insurance premiums have increased substantially because of increased criminality, insufficient risk management and decreased competition among insurance companies.

To solve the problem with high premiums and adverse insurance solutions the most important step is to decrease the damage costs. This can be attained by working systematic with proactive safety management. Unfortunately there are no accepted methods for this today, but according to /1/ it is possible to influence and decrease risks and damages through an aware strategy for safety management. Another reason for systematic safety management is that reinsurance companies often demand this in their insurance solutions.

Because of high insurance premiums, the municipality of Gothenburg started a captive, Göta Lejon Insurance Company. Göta Lejon Insurance Company was founded in 1991 for two purposes; partly to act as a traditional insurance company who offers insurance solutions for administrations and companies entirely or partly owned by the municipality of Gothenburg and partly to act as a catalyst in the city's safety management. The purpose to act as catalyst is to keep damage costs as low as possible. Unfortunately, the damage costs have increased substantially during the last couple of years. The profit that Göta Lejon Insurance Company makes administrates and is after growth used to increase the safety of the municipality of Gothenburg.

In 1997 the board of municipality in the City of Gothenburg decided a safety policy with the objective to conduct the city's safety management. When it comes to methods for safety management you can among other things read: /2/

- Safety management shall be operated by all employees within the municipality of Gothenburg. Safety manager or similar coordinates the safety management within their units.
- Board/committee establishes additional comments to the overall safety policy considering special demands within each activity.
- Administration/company documents the safety management activities in an action programme. The programme shall also give information about improvements and delegations considering safety management.

Analysis of the current situation

With help of statistics and interviews one of the objectives in the report is to make a comprehensive analysis of the economic consequences of fires, burglaries, vandalism and water damages and of the safety culture in the municipality of Gothenburg.

Two kinds of statistics have been studied, fire frequency and damage costs. The statistics come from Göta Lejon Insurance Company and from Greater Göteborg Fire and Rescue Services and the years that have been studied are 1999-2002.

The fire frequency has been calculated for preschools, compulsory schools and homes for elderly. The objective with this study was

to see if there are differences between different sections of Gothenburg when it comes to fire frequency. To investigate if the differences that were found were for real and not by mere accident a hypothesis test was made.

The statistics of damage costs was divided in two parts, one part that studied fire damage cost within preschools, compulsory schools and homes for elderly and one part that studied damage costs within different sections of Gothenburg.

The results of the statistical investigation show that damage costs have increased over the last couple of years and that some sections of Gothenburg have a higher level of damage costs than others. Those sections are Bergsjön, Gunnared and Lärjedalen. Högsbo together with Bergsjön, Gunnared and Lärjedalen also have considerably higher fire frequency than the rest of Gothenburg.

To see if there are some other similarities between the sections of Gothenburg mentioned above, an investigation about social circumstances was carried out. This study showed that Bergsjön, Gunnared and Lärjedalen have lower income, higher rate of people living on social grant and less people with university education compared to the rest of Gothenburg. This result agrees with the result in /3/ where the conclusion is that the fire risk is greater in districts where people are socially under privileged.

As mentioned earlier the analysis of the current situation also included a part of safety culture. Safety culture is a concept that mostly has been used in nuclear-, off shore- and air force industries. The safety culture discussion is that damages not only happen because of lacks in technical systems, the organisation also plays a big part and many damages can be prevented if the safety culture is good in the organisation.

Safety culture has been investigated in municipal activities and interviews have taken place with headmasters and directors for preschools, compulsory schools and homes for elderly. The objective with the interviews has been to answer following questions:

- At what level is safety management in preschools, compulsory schools and homes for elderly today?
- Attitudes to safety management?
- Which are the shortages and advantages of safety culture in the studied activities?

The level of safety management today is not satisfactory. Insufficient education has led to inadequate knowledge in how to protect properties from damages. This is shown by increased damage costs, damage costs that in several cases easily could have been avoided. The safety management does not have straight goals and this of course contribute to the lack of safety management.

Safety management is not included as a natural part for employees and therefore working with safety issues feel like an extra stress. All activities in the municipality of Gothenburg are slimmed-down which follows that other work assignments come first and safety issues get low priority.

An obvious weakness in safety management is that a straight responsibility divide is missing ande there are no co-ordination or overall picture around safety management.

The following problems have been identified and summarize the analysis of the current situation concerning safety management in the City of Gothenburg:

- The safety policy of the City of Gothenburg is not well known and implemented in the city's different activities.
- People who are responsible for property safety do not always know their responsibilities. Furthermore they don't have enough education, time and money to work with safety issues on a satisfactory level.
- There is a lack of comprehensive approach concerning safety management in the City of Gothenburg.
- The damage costs are high and have increased substantially during last couple of years.
- Lacks in the collection and treatment of statistics make it difficult to take the right preventive measures.
- Follow up and evaluation of the safety management are not made continuously and documentation is often missing.

- There are no active networks concerning safety issues.
- Stress among employees influence the safety management negatively. Safety issues are not prioritised.

Model for safety management

The main purpose of a model for systematic safety management is to decrease the municipality of Gothenburg's damage costs. If the damage costs decreases there will be more money for preventive measures which decreses the damage costs even more. Figure 1 below describes this discussion.

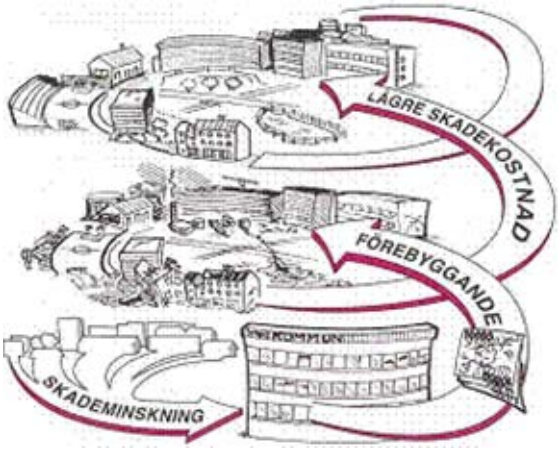


Figure 1, The effect of good safety management and decreased damage costs. /1/

One important part of a model for systematic safety management is to identify the different participants and their responsibilities. In the muncipality of Gothenburg all employees have a responsibility when it comes to safety management activities but some participants are more involved than others. These are:

- The board of municipality
- Göta Lejon Insurance Company
- Greater Göteborg Fire and Rescue Services
- Safety co-ordinators
- Property managers
- Actvity managers

These participants have different responsibility areas and tasks, but due to finite space the reader of this executive summary is refered to the full text report.

Besides a legible organisation with clear responsibilities the following components have been identified to fulfill the purpose of systematic safety management:

- Risk analysis
- Action programme
- Procedures (routines)
- Education
- Documentation
- Follow up and evaluation
- Statstics

The components mentioned above are of big importance but you mustn't forget that the quality of safety mangement activities strongly depend on the motivation and engagement among the participants.

References

/1/ *Säkra hus - Säkerhetsarbete för kommunala verksamhetslokaler* (1996) Svenska kommunförbundet. Kommentus förlag. Stockholm.

/2/ Göteborgs Kommunstyrelse (1997) Säkerhetspolicy Göteborgs Stad, beslutad 1997-02-26.

/3/ Melkersson, Marie (1997) *Brandfrekvens och samhällsstruktur.* Räddningsverket. Karlstad.

Basic data sets for decision-making on municipality accident prevention programmes – focusing on everyday accidents prevention

Daniel Ekström
Andreas Kräling

Abstract

Based on a new Swedish legislation for accident prevention and protection the support of the establishment of municipality accident prevention programs with documented basic data sets for decision-making is discussed. A division into four documents of basic data sets is proposed. A process is projected for the production, decree and compliment of municipal accident prevention programmes and the documented basic data sets. Content and structure of the action programmes and basic data sets for decision-making on everyday accidents, with consequence on human life, is presented including some support for formulation of measurable goals and hierarchy of objectives. A case study on the city of Malmö is discussed in this context focused on accident statistics based on available data.

Introduction

Through an instituted task on reforming the Swedish rescue service legislation, which to date has resulted in a government bill, a new political area has appeared concerning citizen accident prevention and protection. The bill – *Legislation on accident prevention and protection* – clearly states as national goals that citizens all over the country should hold the rights to satisfactory and equivalent protection against accidents with consideration taken to local conditions. The responsibility to fulfil these rights should lie on the local authorities by accounting of the municipal accident prevention and protection undertakings in *action programmes*.

Methodology and problem

By bringing forward the government bill a number of problems and questions have arisen. These mainly concern how the government's intentions with action programmes are to be translated into municipal strategies that actual creates more effective rescue services and contributes to an increased level of protection for the citizens.

The starting point for this thesis is the demands on action programmes specified in the proposed legislation. Serving as a base for the analysis are the impressions and facts the authors have gathered, foremost from documents preceding the government bill but also from visiting persons of importance concerning this preceding research. Based on the legislation, its preceding work and lessons learned from those who already begun similar work, a proposed content for *action programmes* is presented in the full report. To support the producing of action programmes a suggested series of *basic data sets* and the achievement of those are put forward.

Municipal action on accident prevention

The action programmes shall clearly state the goals for the municipal undertakings and present the risks of accidents that could demand rescue actions from the rescue service. The action programmes should also show how the municipal organisation for accident prevention is arranged and planned. Furthermore shall the ability, and the ability planned to be obtained, to perform rescue service be stated. An important issue concerns if the accident prevention in the municipality should include all types of accident or only those who raise actions from the rescue service. None the less, the action programmes should include accidents in a broader sense than the case is today, and thus embrace other type of accidents than fires.

Our vision of action programmes is that the objective should be to generate a safe environment to the citizens and facilitate an as effective use of public means as possible. To do this it is of great importance that the municipality takes a stand as the central arena for accident prevention, from witch coordination and joint actions are managed.

This can be achieved only by applying an ambitious and serious approach to the action programmes.

Basic data sets

Decisions concerning the municipal accident prevention and protection are based on facts and political values. To support the municipal leadership in this decision-making, creating effective goals and keep the activities cost-effective it takes a well organized execution of analysing the local conditions, resulting in suggested measures leading to improvement. Documented analyses as these are in this thesis called *basic data sets for decision-making*.

The accidents, risks and threats that exist in society span over a wide spectrum of consequences ranging from elderly's fall-accidents to severe events in a state of war. It can be very difficult to at the same time study both the comprehensive picture as well as details in the subsets of the municipality safety undertakings. It is quite likely to assume that the analyses therefore will need to be divided into several unique sets of basic data, to maintain focus in the separate areas specific problems, context and consequences. As shown in figure 1, a division into four different documents is made: *Basic data for everyday accidents*, *Risk analysis for major accidents*, *Vulnerability analysis* and *Analysis of requirements in state of war*.

All of these documents should include requirements and abilities to perform rescue service actions.

This thesis focus on the basic data set for everyday accidents with consequences on human life. The objectives of the basic data sets are to produce a groundwork and foundation for ethical based political discussions by giving a detailed comprehensive picture of the local conditions. Furthermore it should present an estimation of likely outcomes of different possible alternatives of action, and support the formulation of measurable goals suitable for follow-up. The basic data sets for decision-making should be subjected to requirements such as they should be distinct and comprehendible, developed in mutual understanding, founded in the municipality's comprehensive view and documented as well as easy to access.

Action programmes

With the proposed legislation a number of demands are put forward regarding action programmes. It is stated its content, function and objective it is supposed to fulfil. Based on amongst other things the demands mentioned, a proposal is presented in the full report regarding contents and structure of accident prevention action programmes including a comprehensive section describing the local conditions, goals and safety undertakings in the municipality.

Linked to this are sections describing specific administrations and services, their undertakings, abilities and processes.

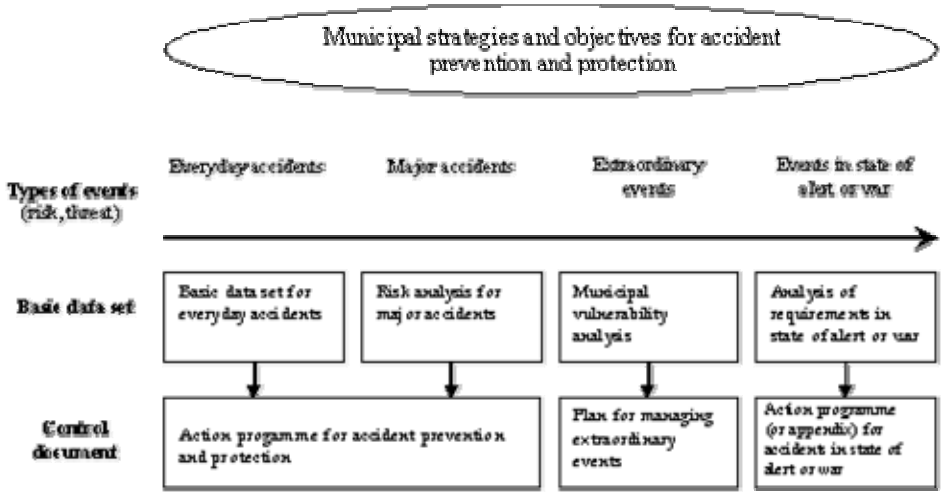


Figure 1: Different documents.

In the same way that economics, environmental and equality issues are handled, the producing of basic data documents and action programmes need an effective cross-sectional cooperation in the municipal organisation. The organisation surrounding the work on action programmes should be formed such that it supports the process starting in analysing the local conditions, leading to a decreed action programme and ending in evaluation and follow-ups. In this process three important functions has been identified as being: *the governing function*, *the analysing function* and *the executive function*.

The process, which is presented in the figure 2, is characterized by a large need of competence, resources, coordination and joint action and its success is based on how well these needs are met.

Statistic data processing

To satisfy the need for basic data on everyday accidents this thesis describes possible contents, input data and processing of data to form accident statistics, accident development and personal risks for individuals. The most central parameters in registering accidents are a subdivision into accident types and position of the accident. The accident statistics are in this thesis presented in different consequence classes: *fatal*, *severely injured* and *slightly injured*. The statistics are presented as absolute number, incidence, years of lost life, time of treatment and accidents proportion of total amount (all causes).

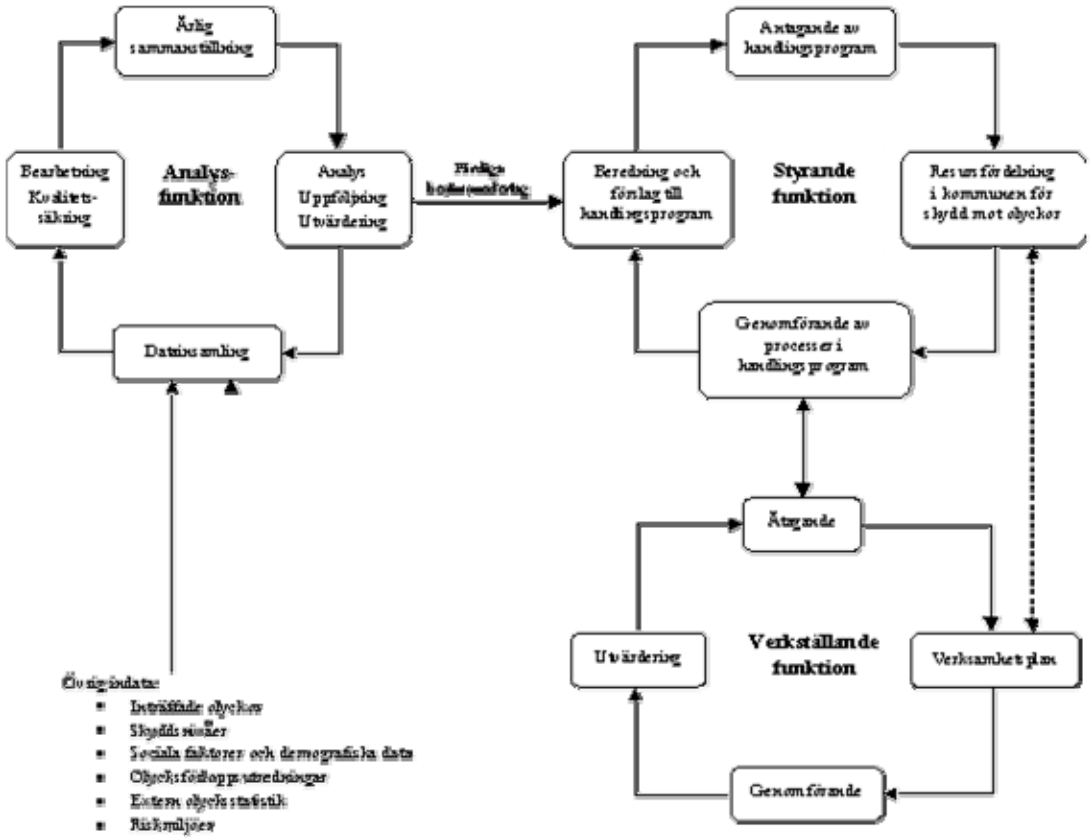


Figure 2: Suggested process for production, decree and compliment of municipal accident prevention programmes and documented basic data sets (figure in Swedish).

To this is suggested to connect social and demographic facts, levels of protection, accident investigation reports, external accident statistics and an inventory of specific hazardous environments.

When the detail level increases or the sampling space decreases in time or space the statistic foundation can be insufficient to support qualified assumptions regarding a municipality's accident related risks. In general solely use of data on fatal accidents will create an insufficient picture of the accident situation, giving room for random variations. Therefore it is necessary to gather information on severe injuries as well and preferably also on slight injuries. The information gathering requires cooperation with the medical services. A complement to study incidence in accidents could be to study other weaker variables as measurable attributes like the occurrence of functional smoke detectors.

As an instrument in follow-up and to support the decision-makers with the formulation of measurable goals, a hierarchy of goals is presented in the full report, based on several measurable attributes together with the calculation of an all-embracing damage- and goal index.

The most effective way to use resources is probably to evaluate different alternatives of action in advance. Useful tools for these evaluations are models calculating the achieved social benefits. These models have a high demand that the analysis actually resolves the problem in its specific context and that uncertainties are handled in a proper way.

Case study

A case study has been performed with the objective to present parts of the basic data set for preventing everyday accidents in the city of Malmö, based on present available input. The results maintain high standard regarding its ability to present a comprehensive picture of the accident situation in the city of Malmö. Because of the way accidents are registered at present it is not possible to present material based on the actual position of the accidents. Together with the lack of social and demographic data it has not been possible to present any analysis on the relation between such data and the occurrence of accidents. The absent positioning of accidents in combination with time delay in the statistic input data, ranging from 1,5 to 2 years, leads to the conclusion that local municipal accident registering is preferable.

Conclusions that can be made from the results are that the distribution of accidents is similar to national figures in general. As shown in figure 3 the accident distributions show a heavy representation from elderly people of both genders, mainly because the large number of fall-accidents. In almost all ages and types of accidents the male sex has a higher incidence than females.

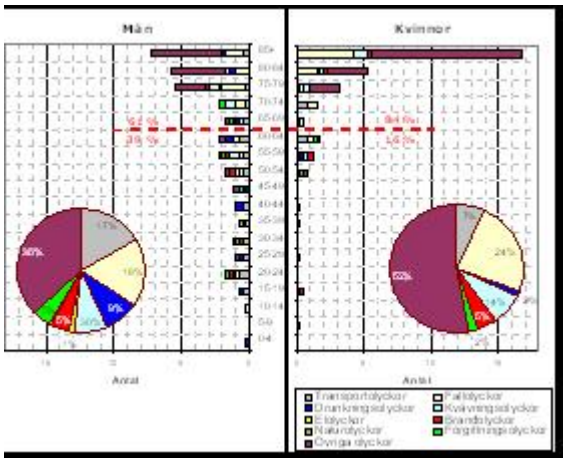


Figure 3: People killed in accidents per year in Malmö, 1997-2000. In average 70 fatalities per year.

As a complement to the absolute number of fatalities the years of lost life (YLL) is shown in figure 4. The figure shows a large contribution of males of all ages.

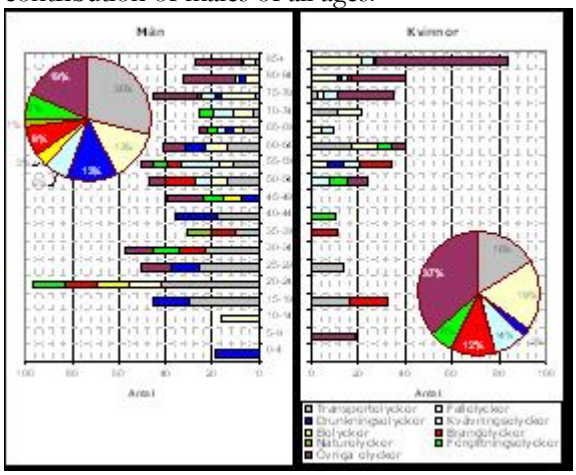


Figure 4: Years of lost life in accidents per year in Malmö, 1997-2000. In average 1 470 YLL per year.

Risk and safety work in Swedish communities

Frida Niméus

Abstract

The purpose with this report is twofold. 1) To examine the safety-work in Swedish communities today, and to compile examples of present models to achieve safe communities and 2) how progressive changes can be integrated into the present work.

The aim is to counsel community´s risk- and safety work through describing different safety actors, give suggestions on present models to achieve safe communities, summarize the laws that govern and influence a safe community and finally to give suggestions on how the competence achieved through the new professional *Fire, rescue and safety training* can be utilized in risk- and safety work.

A brief summary of the contents and conclusions of the report are that the development that occur today in the area of the community's risk and safety work thru new education, increased cooperation and new and coming laws is a step in the right direction towards higher safety and better handling of accidents. The Swedish public sector in a whole has to increase the engagement and the resources regarding risk and safety work.

Introduction

The town districts and the society in Sweden stand before a new risk and vulnerable situation, which requires new way of thinking regarding risk- and safety issues. A new structure regarding safety is getting created through new laws[1] and a new two-year education for the professional *Fire, rescue and safety training*[2]. To create a safer community, the societies' different safety participants have to cooperate, in order to reduce the risks and vulnerability and to increase the capacity to handle accidents and crises.

The purpose with this report is twofold 1) to examine the safety-work in Swedish town districts and 2) how progressive changes can be integrated into the present work.

The aim is to counsel community risk- and safety work through:

- Describing different safety participants involved in the areas of responsibility and co-operation.
- Give suggestions on present models to achieve safe communities.
- Summarize the laws that govern and influence a safe community.
- Give suggestions on how the competence achieved through the new professional *Fire, rescue and safety training* can be utilized in risk- and safety work the most optimal way.

One expectation is that this work can be used as a guideline for the different safety participants in the community. The students at the education, *Fire, rescue and safety training*, can use this report as guidance, and the Swedish Rescue Agency can use it in the work of developing the education. During the work with this thesis, interesting areas and questions has turned up, which has not been able to study in the line of this project, but they can be the base for further studies.

Methods

Participants

The research has been made by literature studies, interviews and questionnaires and by attending conferences and meetings regarding the issue. Conducting interviews and questionnaires where chosen as a method to verify and to gather information concerning how Swedish town districts are working and thinking of risk and safety work. Interviews were made with the director of two Swedish town districts, with representatives from both the Swedish Rescue Agency and the Swedish Association of Local Authorities. Questionnaires where sent to all director of the public administrations in the two town districts and the response where 67 % contra 50 %.

Measures

The interviews and questionnaires assessed following five major variables:

- Definition of risk and safety
- Town districts' risk and safety work

- Co-operation between public administrations
- Laws that govern and influence the work with risk and safety
- How the competence achieved through the new professional *Fire, rescue and safety training* can be utilized in risk- and safety work

Discussion and Conclusion

The contents and conclusions of the report can be illustrated by a metaphor, between the community and a bicycle. Risk and safety work in the community can be described by the figure below.

The hub is the essence of the bicycle and symbolizes all the inhabitances. The different spokes represent the different participants in the town districts that work with risk and safety issues and the surrounding tire and rim coordinates the different participants work.

The chain symbolizes the cooperation and exchanges of knowledge needed between different districts and participants. The saddle represents the government authorities and the work they make for the inhabitances safety. Our parliament and government control and maneuver the community, which is comparable to the handlebars on the bicycle. On the luggage carrier the participants carry different models and tools which they can use for risk and safety work. The bicycle and the community need to have pedals to rotate in order to get somewhere and to follow the development in the society. Examples of pedals in the community are new laws and educations.

The public administrations, trade and industry, government authorities and the inhabitants are the bases for an efficient safety work. A town district rules by a local authority that decides financial frames and goals.

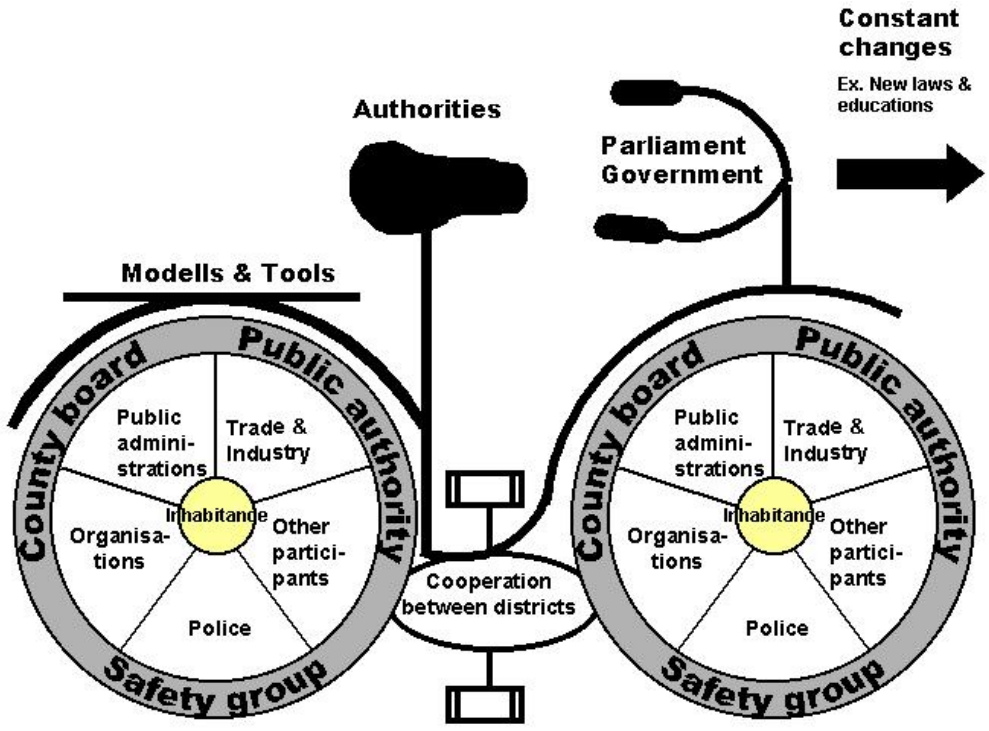


Figure 1, The bicycle summaries the four aims of the report and their conclusions.

Conclusions from the thesis are that the traditional way risks have been prevented are by the different participants individually, and the problem with that is that everyone tends to think to narrow and not use each other's knowledge. There are risks everywhere in the community and to prevent them everyone has to be involved. To reach the best result, responsibility and co-operation between the different participants is needed, from the individual inhabitant to the community party. In some town districts the different safety participants has formed a safety-cooperation-group. It fulfills a good purpose and should be used in a greater extend.

In order to improve the exchange of information between the different participants it is important to use common models and tools[3], which standardize the safety work. One example is to collect, analyze and follow up the joined statistics for accidents and near-accidents in the town district[4]. There are today several models that contain different safety criteria that define a safe town district. The idea is that all participants should have the same criteria and goals in order to reach the best result and to initiate increased cooperation. There are also pretend-games that can be used to practice realistic situations of crises in order to increase the preparedness and cooperation[5].

The community's increased vulnerability and demands on higher preparedness within the authorities against disturbance and strain are accomplished thru new and coming laws for risk and safety work.

The following are examples on how the competence from the new education, *Fire, rescue and safety training*, can be used within the community's risk and safety work. Primary it is important to maintain the traditional fire brigade, but to increase their preventive work. Other important assignments can be to organize education for the employees and inhabitants in the town district in order to increase the safety and reduce accidents. The new workers can be safety organizers within different authorities and industries or be the head of a safety cooperation group that contains people from the public sector, businesses, police and other organizations. They can also work with different models and tools in order to create a safer town district.

The author's final thoughts are that the developments that occur today in the area of the community's risk and safety work thru new education, increased cooperation and new and coming laws[1] is a step in the right direction towards higher safety and better handling of accidents. The Swedish public sector in a whole has to increase the engagement and the resources regarding risk and safety work. To our help there will soon be a new category of workers, *Safety and rescue workers*, from the new education *Fire, rescue and safety training*[2], which will be a great help in the strive to reach a safer community.

Acknowledgements

I would like to express my sincere gratitude to all my supervisors, Sven Erik Magnusson and Jerry Nilsson at the Department of Fire Safety Engineering, Lund University and Martin Adolfsson and Thomas Andersson at the Swedish Rescue Service Academy, Skövde.

Many thanks are also directed to all participants taking part of the interviews and questionnaires. Finally, I distribute special thanks to my family and friends for all their love and support.

References

[1]Betänkande (SOU 2002:10) Reformerad räddningstjänstlagstiftning

[1]Förordning (2002:518) med instruktion för Krisberedskapsmyndigheten

[1]Förordning (2002:472) om åtgärder för fredstida krishantering och höjd beredskap

[1]Lag (2002:833) om extraordinära händelser i fredstid hos kommuner och landsting

[2]Räddningsverket (2002): *Utbildning för skydd mot olyckor,* Räddningsverket, Karlstad.

[2]Räddningsverket (2000): *Förändrad utbildning av den kommunala räddningstjänstens personal*, Räddningsverket, Karlstad.

[3]Svenska Kommunförbundet (2001): *Verksamhetsanalys och säkerhetssamordning – Metod och vägledning*, Svenska Kommunförbundet, Stockholm.

[3] www.srv.se/funktioner/frameset/

[3]ÖCB (2000): *Robusthet på grannskapsnivå*, ÖCB, Stockholm

[4]Bostedt, G. & Larsson, A.K. (2001): *Systematiskt arbetsmiljöarbete i Enköpings kommun – en utvärdering av Incidentrapportering via Internet*, Mitthögskolan.

[5]Olofsson, N. (2001): *Aktörer i Risklandskapet - Ett interaktivt spel om risk och sårbarhet i moderna stadslandskap*, Lunds Universitet, Lund.

Proposal of a new route for dangerous goods in the city of Helsingborg - A comparison between three methods for risk analysis

Daniel Jönsson

Abstract

This article is an executive summary of a master thesis at the program for Master of Science in risk management and safety engineering at Lund University. The work is financed by the city of Helsingborg in the southern part of Sweden. There are three objectives of the report:

- Perform a risk analysis of the transportation of dangerous goods to the harbour area in Helsingborg, and suggest one or more routes as the best alternative.
- Decide which minimum distances, from route to other facilities, is appropriate.
- Compare three different methods for risk analysis. The methods are one used in Gothenburg, one Dutch method (CPR18E) and a regular CPQRA.

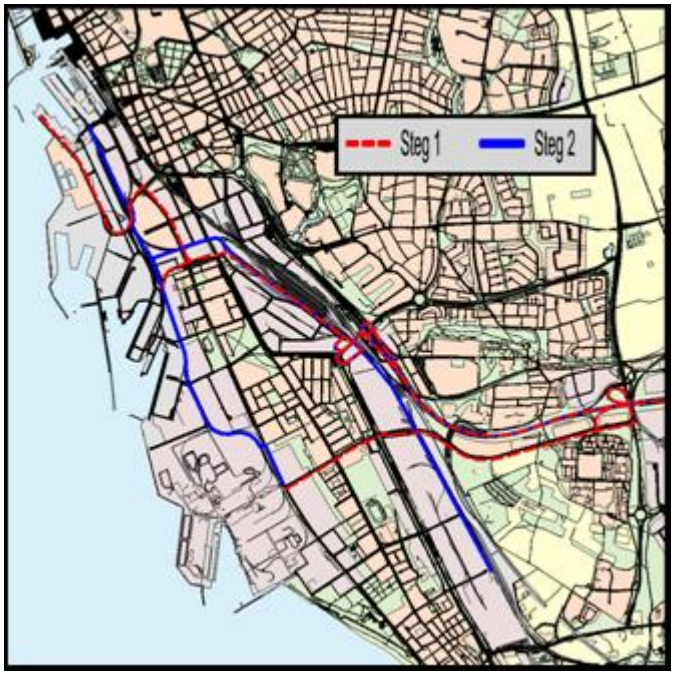
This report will be used in the further city planning in Helsingborg.

Proposal of a new route for dangerous goods in Helsingborg

A route is planned in the north-south direction in the harbour area. This route is to be connected to the national highway system (routes E4/E6/E20). The report shows that the best connection is the use of the street Rännarbanan in combination with a new street long side the railway tracks to the harbour. All three methods support this solution.

The first step gives the city the possibility to develop the urban area Gåsebäck, which today is highly dominated and surrounded by a route for dangerous goods and the rail yard.

When the second step is taken it will be possible to explore the two areas Miatorp and Planteringen. Today they are dominated by one leg of the route of dangerous goods to the chemical industry.



The first step will not change the societal risk much. This is because today the route is very near one residential area, and the new route in step 1 goes near another residential area. But step number 2 will lower the risk, by not being located close to any residential area.

Figure 1 shows the societal risk calculated by the Dutch method, CPR18E. The black line illustrates the risk criterion and it's accepted to have a higher risk than that. But it's recommended that the risk should be lower or at least be so close to the criterion as possible.

Figure 2 shows the same risk calculated with CPQRA. The criteria are taken from DNV and are often used in Sweden. It's not OK to be above the higher criterion, and the lines should get as close as possible to the lower one. Any risk under the lower criterion can be neglected. The criteria are only recommendations.

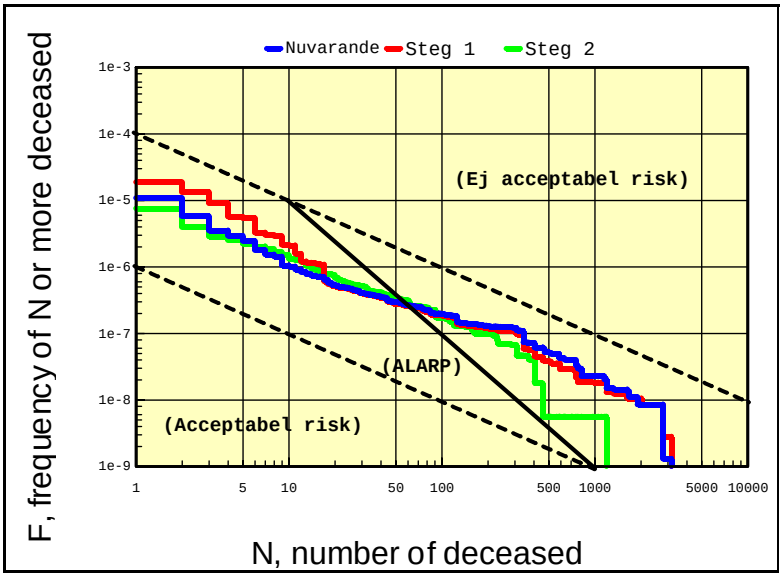


Figure 1, The change of societal risk calculated with CPR18E

***Blue** line is the risk generated by the route of today, **red** is from step 1 and **green** from step 2.*

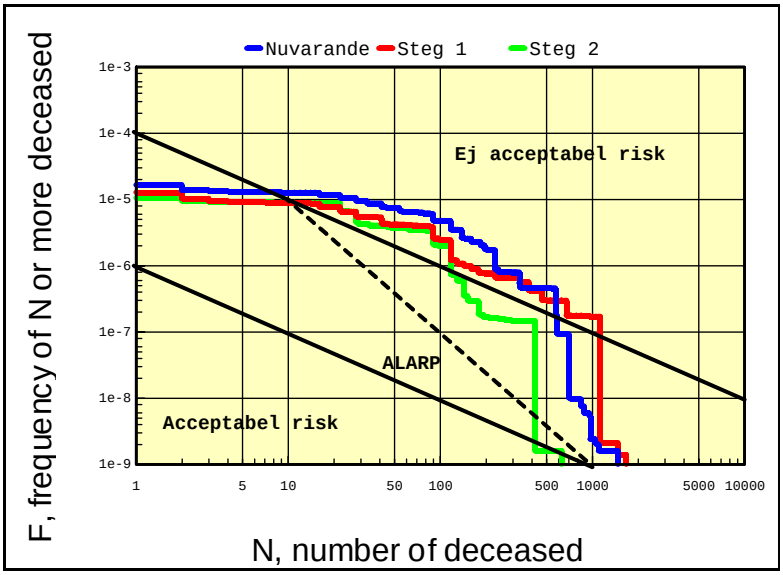


Figure 2, The change of societal risk calculated with CPQRA.

Appropriate distances from routes for dangerous goods

The three methods for risk analysis show that the distances used in the city of Gothenburg, Sweden, can be used in city planning with some changes.

< 50 meters:	No buildings at all
> 50 meters:	Working areas, communication centres (railway stations etc.)
> 100 meters:	Residential buildings, hotels, shopping malls and small meeting places
> 200 meters:	Schools, sport arenas, large meeting places and halls

Shorter distances can be accepted, but will demand preventive measures and a risk analysis that proves that the generated risk is acceptable. The distances are based on the individual risk calculated with two of the methods, CPR18E and CPQRA.

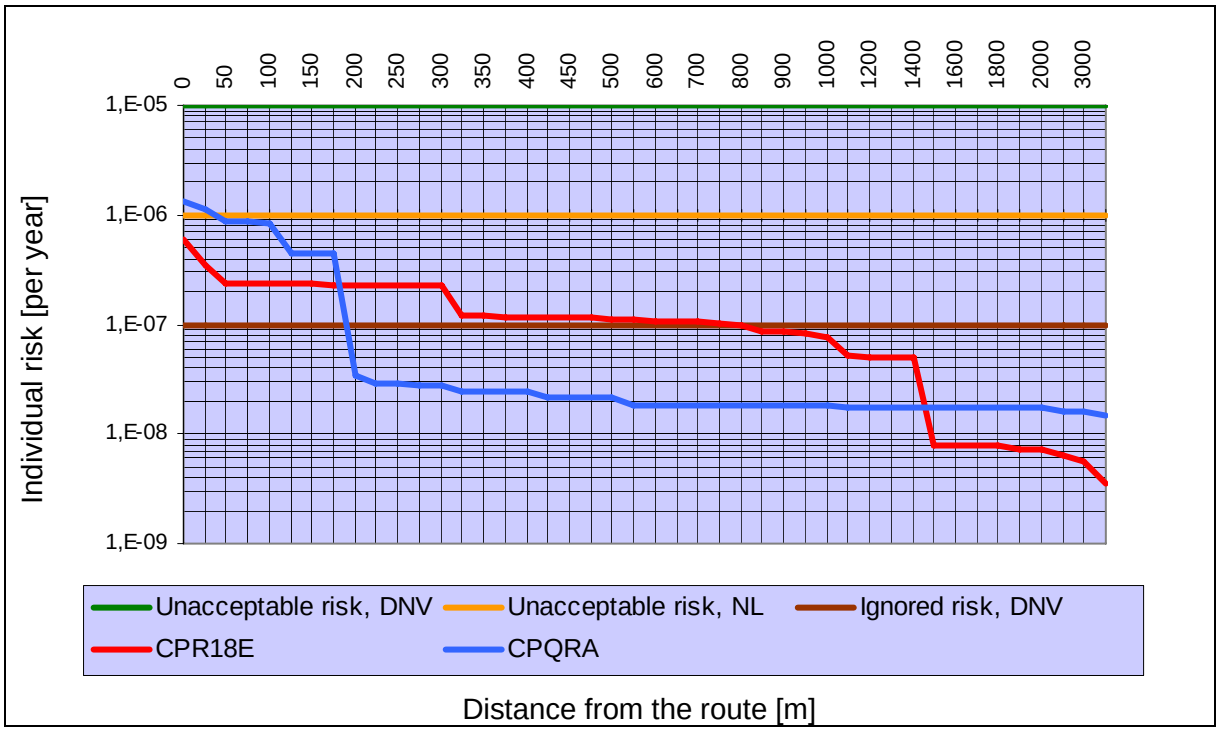


Figure 3, The individual risk calculated with two methods, CPR18E and CPQRA.

The results from the two different methods are similar to each other. After 50 meters the individual risk is lowered radical. This is because the consequences from many of the possible accidents with dangerous goods only reach this maximum distance. A major part of the traffic is flammable liquids like gasoline and petrol.
At worst a total rapture create a pool with a radius of 30 meters and the lethal radiation reaches another 10 meters. At a distance of 50 meters from such accident nobody gets killed. The same reasoning is also valid for most of the toxic or corrosive liquids and flammable, toxic or corrosive materials. Because of that a 50 meters wide building free zone nearest the route is highly motivated. Working areas with industries and offices can be located here. Next dip in the individual risk is at a distance of about 100 meters. Here is it accepted with residential buildings, hotels and small meeting places. After 200 meter the risk calculated with CPQRA is deep below the neglect able risk criterion. Also the risk calculated with CPR18E shows that the risk is acceptable. At this distances sport arenas, schools and large meeting places can be tolerated. These objects

often host many people and can be difficult to evacuate.

Comparison of the methods

Because the lack of national risk criteria in Sweden each risk analyst must decide which to use. Therefore the method from Gothenburg is deriving its own criterion. It would have been better to use an existing accepted method instead. The chosen criterion is much more gentle than normal. In the same time only one category of dangerous goods is used at the time in the risk analysis. The correct way is to calculate the total risk generated by all traffic with dangerous goods. The use of the other methods shows that the result is nevertheless acceptable. This could be due to the fact that more dangerous goods are transported in Gothenburg compared to Helsingborg.

In the Netherlands the access to land is restricted. The properties must be used at the maximum. Not using valuable areas is too expensive. Therefore CPR18E, the Dutch method, is a detailed guideline that uses a standardisation of inputs in the models. This is so that different risk analysis can be compared. Good statistics and advanced models are provided.

The method is only looking at the risk generated by a few numbers of categories of dangerous goods.

Only flammable or toxic gases and liquids are assumed to generate any risk to the society. Class 1, explosives, is not with taken because it is a small category of dangerous goods. But if the probability is so low for an accident the consequences in the other end is much higher. Risk is a product of both probabilities and consequences.

CPQRA is a well-known method and it's up to the user to choose which categories of dangerous goods to involve in the calculations. There is nothing mentioned about the probabilities of accidents with transportation of dangerous goods. Therefore a Swedish method, called the VTI-method, is used instead. This method has received some critic in Sweden because it's using very detailed index for different types of roads and speed limits. It's impossible to quantify the probabilities that detailed.

An interesting fact with the three used methods are the different risk rating generated for the different categories of dangerous goods. Two of the methods ranks mass explosives as the category with the highest risk, while the third method is not looking at it at all.

No method is clearly better than the others. Therefore it's necessary to use at least two of them (CPR18E and CPQRA).

Conclusion

The city of Helsingborg can accept the risks of today without any changes. But it will then be impossible to develop the area further. The route with dangerous goods is today located very near residential buildings. It is therefore recommended
to move the traffic.

Ranking	Gothenburg	CPR18E	CPQRA, VTI
Most dangerous	Mass explosives	Flammable gases	Mass explosives
↑	Toxic gases	Toxic gases	Oxidizers and organic peroxides
	Oxidizers and organic peroxides	Toxic liquids	Flammable gases
	Flammable gases	Flammable liquids	Toxic gases
			Toxic liquids
Least dangerous			Flammable liquids

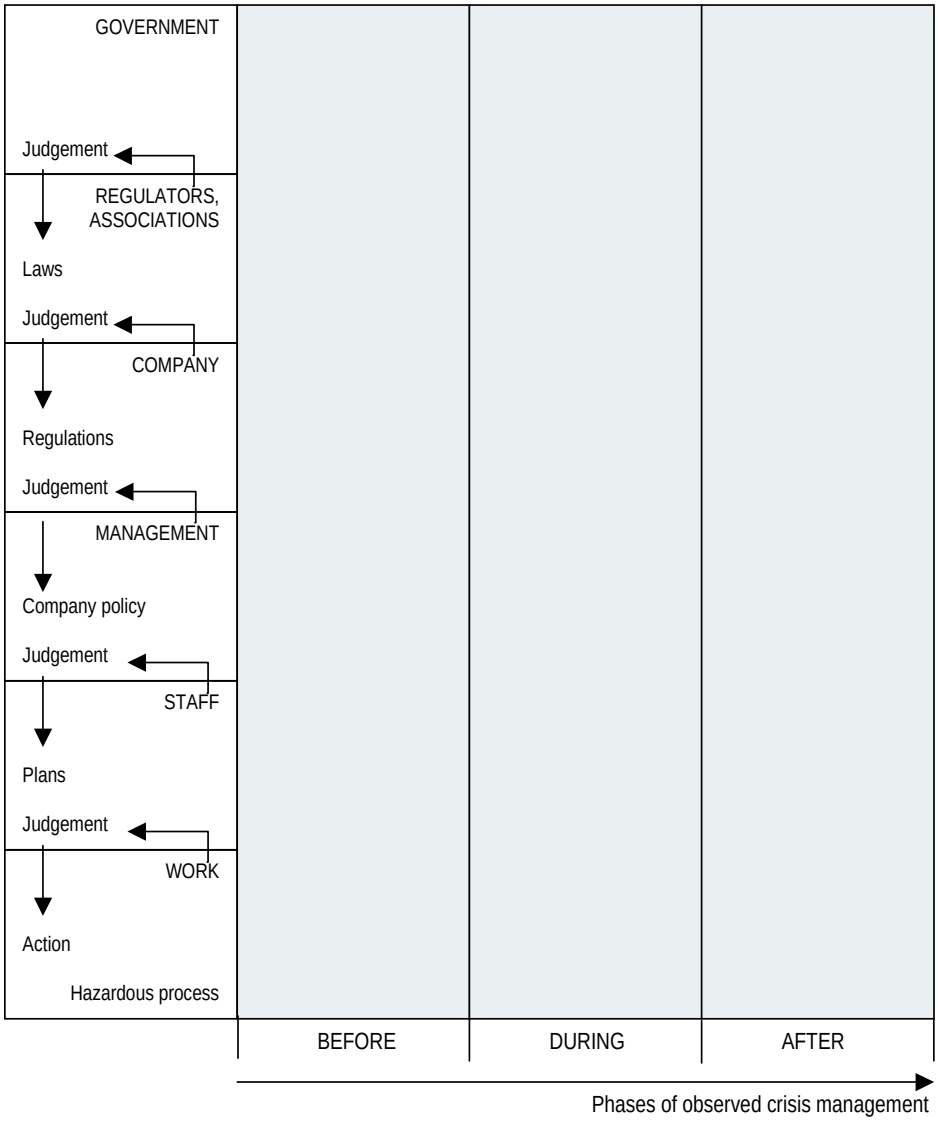
The Swedish Rescue Services Agency's Observation Activity

Magnus Nordberg
Tobias Persson

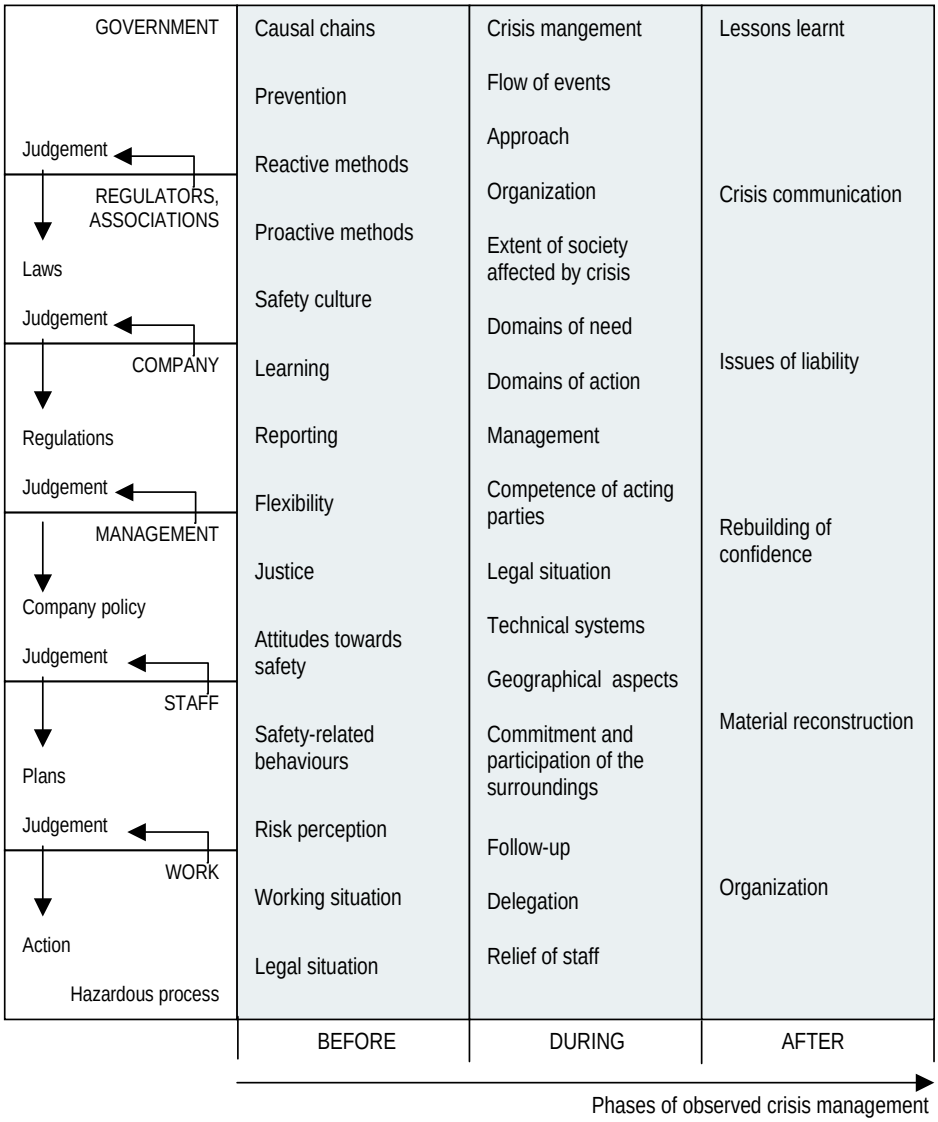
The Swedish Rescue Service Agency has been doing observations on occurred accidents since 1987. The report which this executive summary is about considers improvements for the observation activity. Several problems is identified in the performance of the current observation activity. The most important problems identified in the report were; lack of objective for each assignment, deficiency in analysing discussion in the assignments and a shortage of a theoretical approach for crises management.

The purpose with the report was foremost to construct a model that gives the observers an overall picture of crisis management that they can use to structure, analyse and report the obtained information from an observed accident. The purpose with the model was also to be used in the process of deciding whether or not to initialize an observation.

On the basis that the activity for observers needs to be improved, several models were studied to eventually form the model for observers. This model, shown below, is the heart of the report. The model is foremost a combination of two models, a socio- technical model and a model over the fire brigade activities in safety work. This combination results in an overall picture of crisis management.



There are keywords inserted in the model for observers. The purpose with keywords is to concretize the different parts that can be objects for an observation. One of the main aims during the model development was to make the model dynamic so that people could use it during different kinds of observations. Therefore, the purpose with the keywords wasn't to reflect the reality, but rather just to give the observers and the decision makers a hint of what kind of things that could be observed. How to include observations in the risk management process is described in the report. Perception is a very important factor when accidents are observed and one of the chapters in the report especially focuses on this issue. It's not possible to make an objective observation of an accident; which is also discussed in the report. The ambition for an observation must be flexible because of the dynamic environment. A proposal how the Swedish Rescue Service Agency could let the ambition vary for different observations is presented below.



High	• Observers present during the critical phase and one or two follow-up visits •Optimal make-up of the observer group •Depth of analysis of higher priority than rapid release of report •Extensive distribution of report and other forms of presentation
Medium	•Observers present during the critical phase and one follow-up visit •Optimal make-up of observer group • Depth of analysis of high priority, but rapid release of report equally important • Extensive distribution of report and possibly other forms of presentation
Low	•Only one observer visit •One or a couple of observers •Rapid release of report has high priority •Selective distribution of report

Proposals for improvements for the observation activity are given in the report. The main conclusions from the report is:

- Education for the observers is needed.
- The model for observers should be used in the education.
- The sequence of work for the observation activity should be applied.
- Perception should be noticed during an observation procedure.
- Different levels of ambition must be allowed.
- The relationship between the Swedish Rescue Service Agency and other activity's (who are doing observations on occurred accidents) needs to be defined.

Methods for Risk and Vulnerability Analysis – Regarding serious events in the area of process industry and transport of hazardous materials

Johan Ingvarsson
Annika Roos

Abstract

In this report, methods for risk and vulnerability analysis of technological infrastructure and transport are examined. Fault Tree Analysis, Event Tree Analysis, and QRA can, along with Anticipatory Failure Determination, Hierarchical Holographic Modelling, and System Action Management, be used as methods for risk and vulnerability analysis of technical infrastructure. For risk and vulnerability analysis of transports, new methods have to be invented. It is a serious problem that there are no satisfactory methods for risk analysis of transport of hazardous materials. The methods that must be invented could for example be based on quantitative approaches such as the concept of Hot spots.

The standards are being raised on the preparedness of society to manage serious crises. One way of doing this is by legislating the performance of risk and vulnerability analysis. There are, however, no directions on how these analyses are to be performed. The purpose of this thesis is to examine what methods can be used for risk and vulnerability analysis of technological infrastructure and transport. As a starting-point, traditional methods for risk analysis have been used.

An inventory of existing methods for risk analysis regarding human reliability as well as technical and organizational aspects is performed to start with. The methods that are, in addition to being applicable to risk and vulnerability analysis, by nature quantitative and result in an absolute measure of risk, is chosen for further analysis. The methods complying with these criterions are Fault Tree Analysis, Event Tree Analysis, Quantitative Risk Analysis and Method for risk analysis of the transportation of hazardous materials by road and rail. The four methods are further dealt with studying the relationship between what is put into the model and what comes out and how this will affect the methods practicability and applicability as method for risk and vulnerability analysis.

Regarding Fault Tree Analysis, the analysis points out the size of the tree, the parameter's position in the tree and the kind of logic gate connected to the parameter as the most important elements to the result. The larger the tree and the lower the parameter is positioned, the more important to the result the separate element is. The analogous analysis for Event Tree Analysis show that the only element that affects the impact the parameter has to the result is the size of the tree; the larger the tree, the less important variations in the separate parameter are.

The difficulties or problems in using Fault Tree Analysis and Event Tree Analysis lies not in the calculation models, but in identifying all possible events and their probabilities/frequencies. Reliable data for the scenario's probabilities/frequencies or methods for dealing with unreliable or not existing data is required. Despite these problems, the methods are considered applicable as methods for risk and vulnerability analysis.

The analysis of the Method for risk analysis of the transportation of hazardous materials by road and rail show that it is not applicable as method for risk and vulnerability analysis. The formulas and indices used in the model are not satisfactory justified. In addition to this, many parameters that have large impact on the model's result are treated too roughly and arbitrarily to give a correct description of the actual risk level. More, the analysis shows that railway crossings are not an important contributor to the over-all risk. This does not correspond to the general meaning of crossings being one of the most important parts of the railway system's safety.

Regarding QRA, the analysis shows that damage criterion, plume arc, and population density have so large impact on the result that uncertain values could result in an incorrect description of the risk level. Since Fault Tree Analysis or Event Tree Analysis often are used

as a part of the QRA, the difficulties in identifying all possible scenarios along with appropriate probabilities/frequencies, also appear with the QRA methodology. QRA is, however, a method that is applicable in many situations and despite it's dependency on satisfactory data, the method gives a good and informative description of a system's risk level. Because the extensive and comprehensive analysis of both probability and consequences, QRA is considered applicable as method for risk and vulnerability analysis.

To handle the difficulties in identifying all possible events and scenarios, Anticipatory Failure Determination (AFD) and/or Hierarchical Holographic Modeling (HHM) should supplement the methods mentioned above. AFD is a method that, due to a different approach, facilitates the identification of all scenarios. HHM is a model for structuring problems that facilitates a systematic inventory of possible scenarios.

The issue of addressing proper probabilities/frequencies to different events, especially for human reliability and the influence of organizational factors, can be handled by System Action Management (SAM). SAM is analytical procedure for structuring and quantifying human and organizational factors. The probabilities/frequencies for other factors is also an issue of concern and one way to deal with the problem is to standardize the procedure of risk analysis. Standardization also facilitates the assessment of risks. For example, criterion for the assessment of risk can be used to decide if a level of risk is acceptable or not.

Fault Tree Analysis, Event Tree Analysis, and QRA can, along with AFD, HHM, and SAM, be used as methods for risk and vulnerability analysis of technical infrastructure. For risk and vulnerability analysis of transports, new methods have to be invented. It is a big problem that there are no satisfactory methods for the risk analysis of transport of hazardous materials. The methods that must be invented could for example be based on quantitative approaches such as the concept of Hot spots.

Management and Risk Level in Small and Medium Sized Enterprises – Insurers perspective focusing on fire and business interruption

Måns Bergfeldt
Erik Grahn

Abstract

This report discusses the organizational influences on protection systems which influence the overall risk level. A number of projects concerning the effect of organizational factors on risk have been studied. A model showing the organizational influences on fire and business interruption following mainly fires has been produced. Projects relating to risk management in SMEs have been studied to look at methods designed to work in SMEs. Interviews in 8 SMEs have also been conducted to give insight in the level of risk preventive work and organizational influence. A tool for including the influences of organizational factors in risk surveys through revising the safety culture is presented. Suggestions on methods to work with organizational influence and safety culture in SMEs are finally presented.

Introduction

The project was carried out in cooperation with the Swedish insurance company Trygg Hansa.

Factors within the area of management and management systems as an influencing factor on risk is today structured and considered in a way that reflects the conditions for larger enterprises. Trygg Hansa wishes to develop methods that could help taking organizational influences into consideration when judging the risks in small and medium enterprises (SMEs).

Many notices that the management style, the safety culture a s o are central factors for lowering the risks within a company.

SMEs in general are not large enough to have their own risk manager or a similar position to work with risk management. It is therefore interesting how this work could be carried out with respect to the special conditions of SMEs.

This work will look at how organizational factors influence the risk for *fire and business interruption* with focus on SMEs. This knowledge will be used to suggest how SMEs could work to lower their risks with respect to their lack of resources. A survey tool which helps to include organizational influence will also be constructed as a help for Trygg Hansa's risk surveys.

The used methods are literature studies and interviews. First a literature study was done within the area of organizational influence on risk. The study was a basis for the following work and gave ideas on what methods to use. Interviews were done in SMEs to provide an insight in their problems. During the project Trygg Hansa was involved to discuss the progress.

Organizational influences on risk

This chapter gives a basis for the understanding of organizational influence and what that means.

Within the scientific community and parts of the industry there is today a consciousness that the organization and management influence individual operators or workers and their possible mistakes. A lot of these ideas have according to Akselsson (2001) started at the investigation of catastrophic events such as the nuclear meltdown at three mile island 1979, the chemical release in Bhopal 1984 and the Chernobyl accident 1986.

A simple model to give a basic visualization of hazards, protection and losses is shown in figure 1. The figure can be used to discuss the similarities between organizational accidents as the above mentioned and fire risks. With this basic view all systems containing protection can be included as we discuss organizational influences. Reason (1997) says that the figure is a generalization which does not provide much information but it is still valuable as a base for discussion within an area that is hard to generalize.

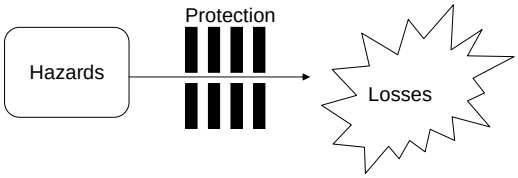


Figure 1, Hazards, protection and losses.

The risk for fire is one example of a hazard which normally is handled with protection systems of different kinds and is covered by this generalization.

Reason chooses to divide failures in active failures and latent conditions. The active failures are done close to the physical processes in a company. They often give direct consequences and often have a short life time. At the investigation of an accident it is easy to close the investigation after the active failures have been identified and someone can be pointed out as responsible. The last 25 years accident investigations have been complemented with the investigation of underlying factors, so called "root causes". Today, active failures are more seen as a result of underlying factors than the main reasons for the accidents. It is widely accepted that people who work in complicated systems makes mistakes and brakes rules for reasons beyond individual psychology. These reasons are what we call latent conditions.

In figure 2 the organizational influences are combined with the model in figure 1. As can be seen in figure 2 organizational factors influence the protection systems.

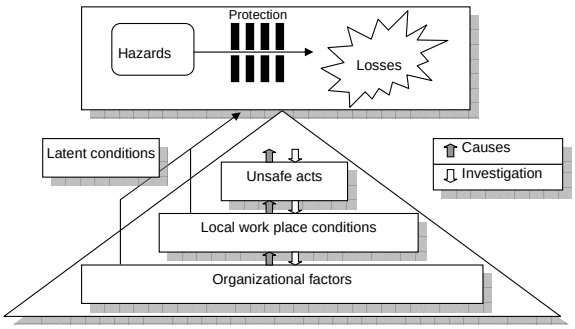


Figure 2, Organizational influence on protection.

Influence diagrams

After studying a number of projects relating to organizational influences on risk a model was created. The objective of the model was to visualize the influences organizational factors have on risk, directly and indirectly. The model is called influence diagrams after the SAM-model, Murphy & Paté-Cornell (1996).

Our focus is on large fires and business interruption following fire or loss of supply systems (Electricity, water, compressed air). This choice is mainly based on the costs of the insurance companies in Sweden.

We use the ideas of influence diagram in the SAM-model because it provides a good overview and it is easy to understand. The model consists of three parts where different factors influence each others from the management level down to an unwanted event. The three parts in the influence diagrams are management, decision & action and physical system. The influence diagram over large fires is presented in figure 3. In the table below the different levels in the influence diagram are explained further.

Table 1, Definitions of the different parts in the influence diagram.

Physical system	Physical system includes everything that is physically present such as sprinkler system, buildings and equipment.
Decision/ action	Decisions and actions carried out by employees who directly work with the system. Often operators and work group leaders.
Management	Management include the factors which management exclusively rules over such as strategies, information, education and organizational structure.
Unwanted event	The event which needs to be protected from.

The factors under physical system and decision and action were created through several brainstorms with revising of the chosen factors. The management part were initially also created through brainstorming (light blue). Later a summary of organizational factors mentioned in the literature were grouped and added to the influence diagram (dark blue). The factors from the literature are quite general and include the first (light blue) factors. We chose to keep the first factors anyway since they are a bit more concrete.

The influence diagram can be used to structure discussions about organizational influences and create understanding about how the risk for large fires can be influenced by organizational factors.

Interviews in 8 SMEs

To verify our thoughts about how risks for fire and business interruption are influenced by management and so called organizational factors we chose to get information from

companies. Interviews were the method chosen to gather a lot of information with a wide content.

The interviews meant to (among others):

- Survey how the management worked to prevent fire and business interruption.
- Examine the connections between the managements ambitions/actions and the employees behavior to see what influence if a company can reach its protective ambition.
- Examine what works better and less good in the preventive work with fire and business interruption and why it works better or less good.
- Look at how different companies work today with respect to their more or less limited resources.

To get a broad view of the interviewed companies and their work two persons where interviewed at each company. One person representing the management where interviewed to give a picture of managements work, ambitions and attitudes. Further one person with good insight in the work "near the floor" where chosen. This person had experience of working with the physical systems and where a work group leader or corresponding.

It is a general conclusion that all organizational factors were considered important for the work and systems in a company. We have found a clear tendency that management does not view time pressure as a problem while people working close to the physical systems do. It is important that this information relevant to the systems quality reaches management and is accepted there.

Other conclusions from the interviews are:

- The knowledge about fire and business interruption is low.
- The fire brigades influence the level of protection to very large extent.
- Insurance companies have great possibilities to influence the companies' investments on fire and business interruption protection.
- Most companies realize the importance of learning from incidents and near accidents but it is not done.

Risk profile

Safety culture					Low			High
	Yes	Partly	No		1	2	3	4
Who within the company is conscious about the companies risks concerning fire and business interruption? - Management				**Risk perception**				
- Heads of unit								
- Work group leader								
- Everyone								
If the employees are conscious about the risks, how did they reach this level of consciousness? Through - Education								
- Common meetings								
- Information leaflets								
- Informal talks								
…and so on…								

Table 2, Part of the tool for risk survey with focus on safety culture.

Method for organizational risk survey

It is the authors' opinion that it is not enough to look at the presence of protection systems when the risk level is examined. If the thought is accepted that the organization on management level will influence the performance of the protection systems and it is further believed that this influence is significant one realizes that this influence must be taken into consideration. We choose to include this

perspective through examining the safety culture.

From Reason (1997) and Akselsson (2001) information about the different parts of safety culture is gathered. The identified parts of safety culture provide the basis for questions that can be used to do a survey on the safety culture. The questions have been influenced by work done by Åsa Ek, phD, Lund University.

An extract from the survey can be found in table 2.

Method for SMEs

Fact cards and working cards have been developed as a suggestion of how methods for lowering risks in small and medium sized enterprises (SMEs) could look like. The way the methods are presented is influenced mainly by the VTT-project on risk management in SMEs, Suokas et al (1999).

The methods aim to raise the consciousness in companies about organizational influences and "root causes". The methods are further meant to introduce the concept of safety culture and help enhancing the safety culture through reporting of incidents and "near misses".

The proposed methods are the following:

- Fact card about organizational influences on risk.
- Working card on organizational influence on risk.
- Fact card about safety culture
- Working card on incident reporting

Conclusions & discussion

The starting point for this work was the methods which have been developed or were under development and that had the intention to measure organizational influences on risk.

These methods have been found not suitable for our use when looking at risks in small and medium enterprises. The methods were mostly focusing on correction factors for a quantified risk and therefore depended on an extensive quantitative risk analysis of the examined company. Some of the methods were still under development. Most methods depended on "expert judgment" at some point were someone gave his/her subjective view on the influences. The "experts" were often persons within the company with good insight in the systems.

It seems as many, especially within industries with large risks, have realized that organizational factors in some way play an important roll for the risk level. It is however our opinion that few have been able to work with good results in this field.

We have found that all organizational factors we have gathered in this work do influence the risk level. Some of the organizational factors have a large improvement potential in the companies we have interviewed. These are knowledge/education, learning and reporting. Time pressure is also an interesting organizational factor. Time pressure is viewed differently at different levels in the companies which indicate problems with communicating and understanding different views.

In the report we propose different methods that can be used in SMEs to work with organizational influence. Will these methods mean lowered risks for SMEs if used? We think the risks will be lowered but we cannot say anything about the order of that risk reduction. It is among others depending on the preventive work in the companies today.

The risk survey tool that is presented in our report has its base in the safety culture in the surveyed company. The tool is meant to broaden insurers view on risks. An interesting question is if organizational factors influences companies risk level in a way that insurers today cannot see. We believe that this tool will add a useful dimension to the attempts to judge the risks in a company.

References

Akselsson, Roland (2001), *Föreläsningsmaterial MTOR, kurs i riskhantering*. Avd för ergonomi och aerosolteknologi, Lund.

Murphy, D. M & Paté-Cornell, M. E. (1996), The SAM framework: Modelling the effects of management factors on human behaviour in risk analysis. *Risk Analysis Vol 16* (Nr 4), p 501-515.

Reason, James (1997), *Managing the Risks of Organizational Accidents*. Ashgate Publishing Ltd, Aldershot.

Suokas, J. & Murtonen & Lepistö, J. (1999), Modern Risk Management Tools for SMEs. *European Workshop an Occupational Health and Safety Management Systems*. 18-19 Mars 1999, Dortmund.

Safety During Test Trips – Analysis and proposal to a handbook

Daniel Johansson
Ann-Catrin Sandström

Abstract

In Saab Automobile AB different kinds of test-driving activities, so called test trips, are carried out during the development of a car. Saab Automobile has acknowledged a lack in routines for safety during test trips, at the same time they want to reduce possible accidents and the consequences of an accident. Therefore Saab Automobile AB is in need for a handbook that considers safety during test trips. This paper briefly describes how the authors have recognized factors that affect risks arising during test trips and how these risks can be reduced. Focus lies on People-Technology-Organization. The results are based on a risk analysis and are presented in a proposal to a handbook for safety during test trips. Further on suggestions to principals for safety management have been given on higher levels in the organization.

Introduction

Examples of different kinds of test-driving activity are winter tests in the north of Sweden, summer tests in USA and Australia and high speed tests on proving grounds around the world. The people who perform test trips are mostly test engineers and mechanics working with the development of the car. These persons have assignments related to testing as well as development in the department. Data have been collected through interviews, observations and literature studies. Identified factors that affect the risks are presented in a hierarchical holographic model where the factors have been divided into different categories depending on if they origin in the comprehensive organization, in preparations or in the atmosphere of the test trip and the performance of the test trip. A careful analysis has been made of each category and thereafter the authors have suggested measures that have to be taken into consideration to have a better test trip atmosphere regarding safety and work environment.

People-Technology-Organization

Focus in the analysis lies on People-Technology-Organization, but what does that mean? A short explanation is given in this chapter. The discussion is based on James Reason's theory /1/.

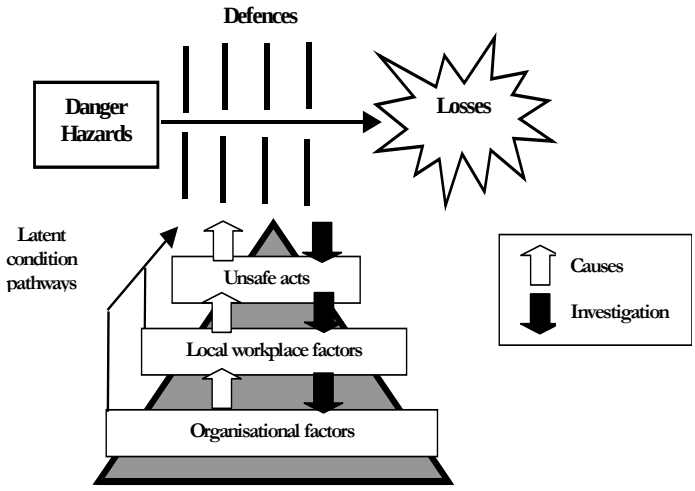


Figure 2, Stages in the development and investigation of an organizational accident.

Lots of accidents depend on social, technical, individual and organizational factors. But often organizational factors are ignored or forgotten. Organizational factors have their causes in strategic decisions and processes such as decisions made by the company board and allocation of resources, for example the right staff in the right place. The organizational factors propagate to local workplace factors. Examples of local workplace factors are a proving ground with undermanned staff, language difficulties and lack of rescue services. Organizational factors and local workplace factors represent latent conditions.

Unsafe acts have their origin in latent conditions such as those mentioned above, staff with wrong education and insecurity. Latent conditions and unsafe acts lead to danger and hazards in the work environment. Often there are different defenses present such as airbags in the car, safety belts, rescue services and

rails. If defenses are missing or break down the danger and hazards develop into losses or accidents.

The discussion above has been a basis for the authors' work with safety during test trips.

Identified factors

Identified factors that affect the risks are presented in a hierarchical holographic model where the factors have been divided into different categories depending on if they origin in the comprehensive organization, in preparations or in the atmosphere of the test trip and the performance of the test trip. In the first category (origin in the comprehensive organization) the following sub categories have been identified:

- Safety culture
- Risk and safety management
- Cost reduction
- Medical check-up
- Social factors
- Test coordination

In the second category (preparations) the following sub categories have been identified:

- Responsibilities and rights
- Working time regulations
- Test trip planning

And in the third category (atmosphere and performance of the test trip) the following sub categories have been identified:

- Climate
- Factors related to countries
- Public roads
- Proving grounds and workshops

Each sub category contains several factors and all together forty factors have been identified.

Conclusions

A proposal to a handbook for safety during test trips is presented based on the result of the risk analysis carried out. Further on suggestions to principals for safety management have been given on higher levels in the organization.

The handbook

The handbook is named *Safety during test trips* and begins with a chapter about the meaning of the safety culture in a company and how Saab should work with risk and safety management. Thereafter Proving team and Home base are described along with how test and following cars should be handled. Further on it is explained when a test captain should be designated, which education is required and which responsibilities and rights test captains and test participants have during a test trip. The authors have explained working time regulations and given a suggestion on how a test trip should be planned. To report risks, incidents and accidents is an important part in the work with risk and safety management. Therefore suggestions on reporting are described in the handbook. Finally accident handling and secrecy are discussed. The last pages in the handbook contain checklists of what to think of before leaving, equipment that must be brought and what to think of after the test trip. Suggestions of ownership and how the handbook should be updated have been given to make sure that the handbook remains a dynamic document. The format A5 is preferable, as this will make it easier for the test drivers to bring the handbook during test trips.

Safety management on higher levels in the organization

Suggestions to principals for safety management have been given on higher levels in the organization. Saab and Technical Development should work to improve the company's safety culture and safety awareness. To do so they should work with a proactive strategy based on three cornerstones; identifying boundaries of safe performance, making boundaries for safe and unsafe performance visible and counteract pressures that drive decision-makers toward the boundaries. Further on it takes a high commitment and an accepted responsibility from directors, company management and decision-makers and participation from everyone in the organization to create a favorable safety culture. Technical Development needs to work with a system where each level is acknowledged. To do so, routines should be established to improve communication and information paths between different levels within Technical Development.

Knowledge, capability and training are examples of important components in risk and safety management. Four types of education have been suggested to work with these components; *Arbetsmiljöansvar för Provledare* (includes responsibilities that a trip captain has for the working environment), common information for test participants, education in medical treatment and education in driving skills. Education and training are important parts of a learning culture that works with constant improvements.

Technical Development should implement clear and simplified routines for reporting risks, incidents and accidents. The aim of reporting is to follow up and analyze the reports to identify latent conditions and lack in safety barriers. The proving team, which is a forum for test trip activity, should be used as a medium to acknowledge risks. They should also be used to collect and spread information about risks, incidents and accidents and analyze and follow them up.

References

/1/ Reason J. (1997) *Managing the Risks of Organizational Accidents*. Ashgate Publishing Limited, Hampshire, UK.

Analysis of Life Safety and Administration of Maintenance Work at OKG AB

Henrik Källström
Fredrik Larsson

Abstract

This report is an analysis of the life safety and the administration of maintenance work at the nuclear power plant of OKG. The analysis is divided into four different sections: administration, radiology, fire and evacuation along with the conventional working environment. The analysis includes literature studies, visits to the plant, interviews of the personnel, Preliminary Hazard Analyses, and reviews of already existing analyses. To further implement the model of Preliminary Hazard Analysis at OKG, a training session has been held. As a result of the analyses, recommendations for risk reducing measures have been given.

Introduction

This report is a master thesis at the Department of Fire Safety Engineering, Lund University, Sweden. The report has been prepared in cooperation with the nuclear power plant OKG AB. This report presents an analysis of the life safety and the administration of maintenance work at the nuclear power plant. The analysis is limited to the reactor containment during outage but will in most parts be usable in all units within the power plant.

In the figure below the reader can get an insight of the reactor containment layout. The explanations in the diagram are given in Swedish, but the most important sections, the drywell and the wetwell, are also marked in English.

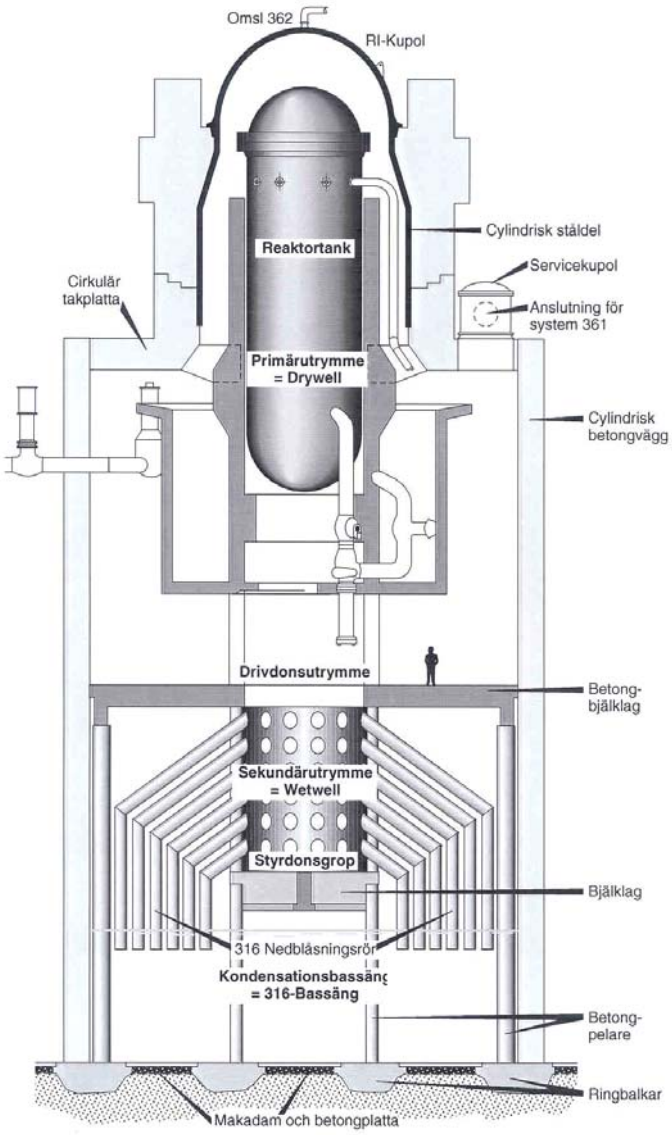


Figure 4, Reactor containment. Reactor 1 OKG

Theory

Theories of interview methodology /1/, safety culture and factors related to physical working environment have served as the basis for discussions and life safety measures. A model of safety culture developed by Ek /2/, based on studies by Reason /3/ and Kirwan, has been studied and discussed as well as adapted for OKG's organization. The same has been done to a model by Rasmussen. A compilation of some of OKG's work to obtain safety culture among maintenance workers has also been carried out. The physical working environment areas considered are radiology, heat and time pressure. These aspects and their impacts on humans have been theoretically described. These aspects were considered because they are relevant to maintenance work in the reactor containment during outage.

Methodology

The analysis includes literature studies and visits to the reactor containment to become aware of the layout of the plant. Interviews and Preliminary Hazard Analyses (PHA) have been carried out as well as reviews of already existing analyses. A gathering of material from incidents and accidents related to life safety from four nuclear power plants in Sweden underlies the analysis contained in this report. At first, a study of the total number of incidents and accidents at the entire plants was performed. To further illustrate the risks in the reactor containments, studies of the containments of Barsebäck and OKG were done. These studies resulted in a categorization of incidents and accidents during maintenance work and are later used to identify risks in the PHAs. At the completion of this study, a method for analysis of life safety was adapted to OKG and training in PHA was also held.

The analysis of OKG's operation and maintenance system (ODU) covered the system's functions, the information running through it, as well as the final product. This part of the report is mainly based on conclusions from the interviews but also the author's judgments.

A Preliminary Hazard Analysis of radiation has been performed with a group of experts from OKG. The goal was to identify the systems that constitute the biggest threats to the staff performing maintenance work.

Three existing analyses of fires in the reactor containment at Barsebäck, OKG and Ringhals have been summarized and reviewed. The conclusion of this review was that new analyses of fire and evacuation need to be done because new and more powerful simulation programs are now available. There are also new theories about human behavior during evacuation.

Similarly, for radiology, a Preliminary Hazard Analysis of the conventional working environment in the reactor containment has been carried out with a group of experts from OKG. Risks such as workers falling, falling objects, and injuries due to electrical current were discussed.

Interviews

The interviews mentioned have been a big part of this project. To gather the opinions and experiences of the employees, forty three qualitative interviews were held. The respondents were chosen from different parts of the plant. Personnel from administrative groups of the company, as well as foremen and workers, were interviewed. The administrative personnel are here categorized as creators of working orders, working permits and safety permits needed to perform work at the site. The questions asked were constructed in cooperation with supervisors at the plant to obtain all the information accurately. The questions cover all the considered risk areas. The administration software, ODU, has been one of the areas together with the more technical risks: radiology, fire and evacuation and at last conventional working environment. Important information concerning the risk areas flows through the ODU software. A model of the information flow and the people involved is shown in figure 2.

Results

Hazards to life have been identified in all the above areas. When possible, risk reducing measures have been suggested. The economic impact of these suggestions has not been considered.

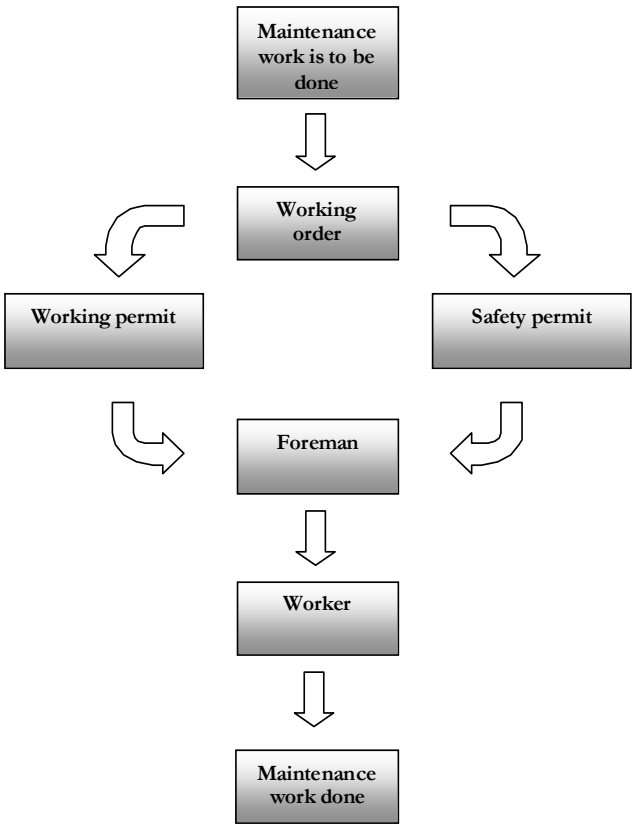


Figure 2, A model of the flow of information before and during maintenance work.

References

/1/ *Trost Jan, Kvalitativa intervjuer, Andra upplagan, Studentlitteratur, Lund, 1997*
/2/ *Ek Åsa, Kursmaterial MTOR (Människa-Teknik-Organisation och hantering av Risk), vt2001, LTH*
/3/ *Reason James, Managing the Risk of Organizational Accidents, 1997, Ashgate Publishing Limited, England*

Health and Environmental Risk Assessment for Road Transport of Hazardous Material

Jonas Roosberg
Dadi Thorsteinsson

A fundamental objective has been to produce a suitable method to systematically analyze and evaluate the health and environmental risks of oil transports. Extensive literature studies have been carried out in an attempt to capture the broad spectrum of the present methods and tools of environmental and health risk analysis.

In order to systematically describe methods, definitions and praxis the report is divided into two main parts:

Part I: General methods in risk management with focus on health and environment

Part II: Case study - Health and environmental risk assessment for transport of hazardous material

Part I

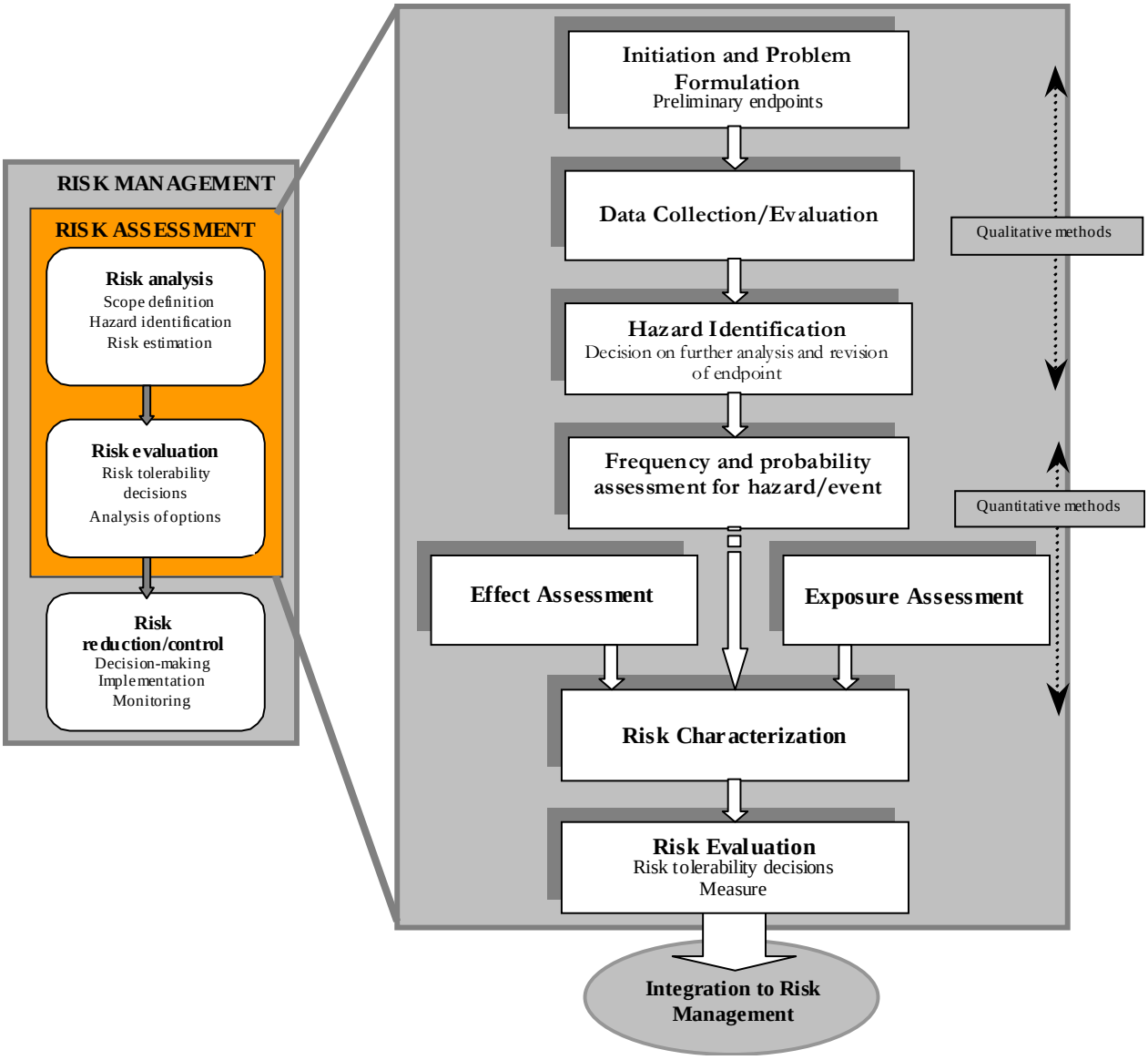
Risk management is often divided into three main areas; Safety (S), Health (H) and Environment (E). These have a general risk management process in common with important concepts and definitions. Therefore the different areas are described in part I.

Different levels of risk analyses are described and how the results can be evaluated in terms of tolerability.

Emphasis is also on the parts that lie outside the risk analysis, e.g.:

- Handling uncertainty
- Communication and Risk Communication
- Management systems
- Risk control options

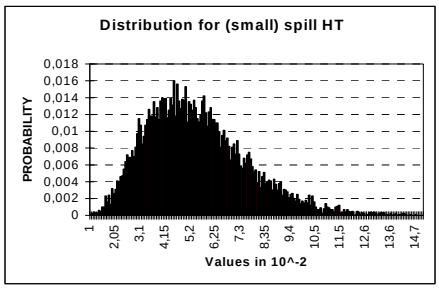
The main objective of the first part is to produce a method for environmental and health risk assessment of road transports of hazardous material.



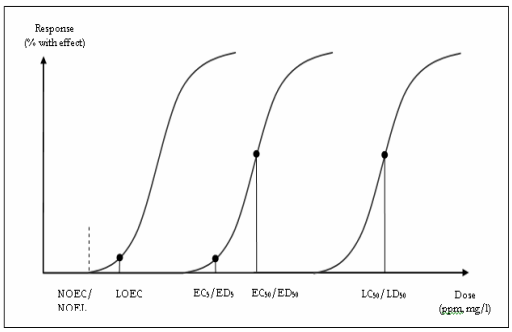
The first steps of the methodology are Problem Formulation, Data Collection/Evaluation and a Hazard Identification. Here it is crucial to have appropriate *endpoints*, and to assimilate enough information and knowledge on the area and chemicals. In order to identify the major risks and to decide whether time-consuming quantitative methods are motivated, a rough analysis should be applied (e.g. an index method). If the risk is substantial scenarios can be selected based on the first steps of the methodology.

The more quantitative analysis in the methodology described above should contain three estimations. These are presented with examples below:

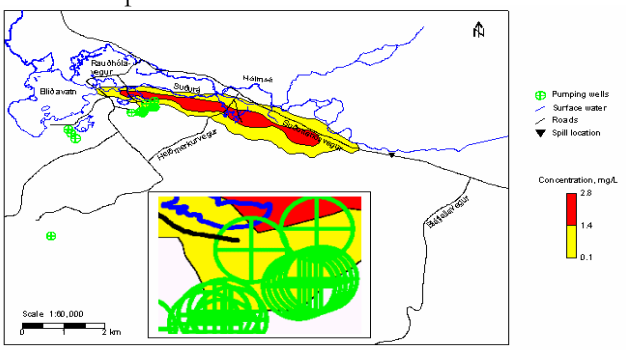
1. Frequency/probability estimation of accident.



2. Effect estimation

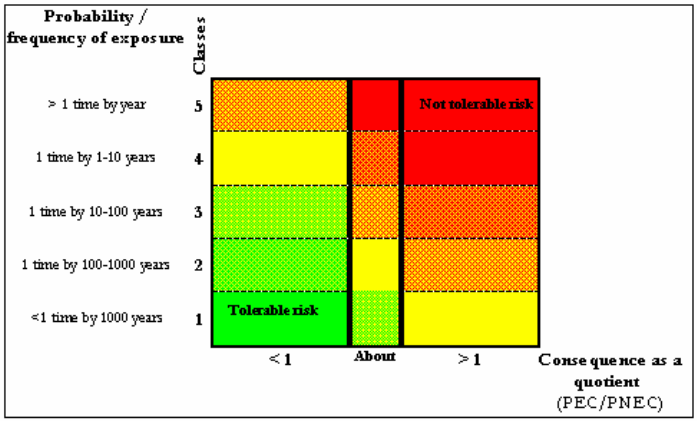


3. Exposure estimation



In order to evaluate the three estimations they need to be transformed to a quantifiable risk value. This is often difficult due to the complexity of health and, especially, environmental risks. One possibility is to calculate a quota of predicted concentration (exposure estimation) and a highest no adverse effect concentration (effect estimation). This quota is a measure of consequence. But in order to measure risk frequency/probability estimation is also needed.

It is often quite straightforward to calculate a frequency for an accident resulting in a chemical spill, but the probability that the specific environment or individual is exposed remains to be assessed. This takes expertise from different fields. The uncertainty in the final risk characterization is therefore substantial but the scenarios can nevertheless be placed in a risk matrix. An example for environmental risks is depicted below.



The advantage of placing the scenarios in a risk matrix is that it helps the risk control discussions. It is even more important to get the control measures implemented. When several stakeholders participate in the risk management process, it is important that the communication works and that there are functioning SHE management systems.

Part II

A case-study constitutes the second part of the report where a stretch of the road Sudurlandsvegur (in Iceland) is analyzed using the methodology from part I. Along the road there are vulnerable areas consisting of a water protection area, a Salmon (salmo salar) river and a lake with Brown Trout (salmo trutta) and Arctic Char (salvelinus alpinus) fishing. Effects on these species constitute the endpoints of the environmental risk assessment.

The health endpoint is the water quality of the water protection area that supplies all the drinking water in Reykjavík. Reykjavík Energy delivers the water so they are stakeholders in this analysis. The chemicals in the analysis are gasoline and diesel. These were chosen partly because they are the most commonly transported chemicals on the stretch and partly because they are the only chemicals that any transport data was available on.

Risk identification of the area is partly conducted with a qualitative Hazard

Estimation, an index method. Based on this rough analysis the environmental and health hazards is substantial, therefore more quantitative methods are motivated. This identification step also aids the selection of scenarios.

Frequency and probability estimation is conducted by collecting data on the transports. A precision tree is constructed with three possible sizes of release for hazardous material transports and one for common heavy transports (equal to small hazardous material release). Due to lack of data frequencies can not be calculated for all scenarios.

The frequency calculations do not consider the exposure probability, i.e. the probability of estimated effects in case of spill.

The exposure estimation consists mainly of two chemical distribution calculations, one via the groundwater predominantly for the health assessment and one via surface water for the environmental assessment.

The health effect estimation assumes that the water quality is adversely affected if the concentration exceeds 0.1 mg/l. This value has been proposed by several oral sources, and is further motivated by reference values presented by the Swedish environmental protection agency. The environmental effect estimation is more complex, and since no appropriate effect values could be found for any of the endpoint species the estimation becomes more qualitative since it must be based on the data available.

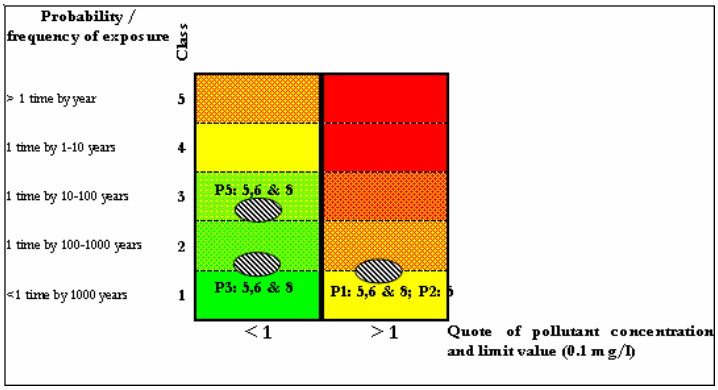
As far as possible a quotient can now be created of the results from the exposure estimation and the effect estimation to form a consequence measure. This is then combined with the frequency estimation in risk matrices of different levels.

Some of the results from the case study are presented in tables and related matrices below.

The risk exceeds the set criteria for both health and environment. The reason is mainly the extent of the consequences. It is left to the stakeholders to decide whether the set criteria are the right ones to ratify the judgments, and in that case which measures to take. Some recommendations are nevertheless given in the end of the report.

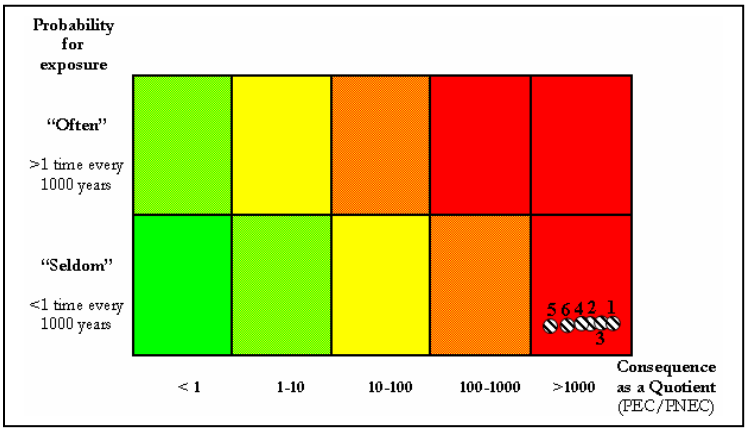
Health risk characterization:

Scenes of accident:	*Scenario (P) with amount of spill:*	Is the limit of 0.1 mg/l exceeded (intolerable)?	Frequency:
4	S1: 50 kg (0,5 ton)	**No**	-
4	S2: 100 kg (1 ton)	**No**	-
5	P1: 32 tons	**Yes**	8×10^{-4}
5	P2: 4 tons	**Yes**	8×10^{-4}
5	P3 & P5: 0.2 ton	**No**	$1,7 \times 10^{-3}$ & $3,4 \times 10^{-2}$
6	P1: 32 tons	**Yes**	8×10^{-4}
6	P2: 4 tons	**No**	8×10^{-4}
6	P3 & P5: 0.2 ton	**No**	$1,7 \times 10^{-3}$ & $3,4 \times 10^{-2}$
7	S3: 3 tons	**No**	-
8	P1: 32 tons	**Yes**	8×10^{-4}
8	P2: 4 tons	**No**	8×10^{-4}
8	P3 & P5: 0.2 ton	**No**	$1,7 \times 10^{-3}$ & $3,4 \times 10^{-2}$
9	S1: 50 kg (0,5 ton)	**No**	-
9	S2: 100 kg (1 ton)	**No**	-
10	S1: 50 kg (0,5 ton)	**No**	-
10	S2: 100 kg (1 ton)	**No**[1]	-



Environmental risk characterization:

Scenario	Anthracene	Benzene	MTBE
P1: (large release)	30 mg/l	1500 mg/l	1.5×10^{4} mg/l
P2: (medium release)	1.01 mg/l	50.5 mg/l	505 mg/l
PNEC/RRV:	0.000019 mg/l	0.017 mg/l	0.05 mg/l
Quotients			
P1: (large release)	1.58×10^{6} (1)	8.82×10^{4} (2)	3.00×10^{5} (3)
P2: (medium release)	5.32×10^{4} (4)	2970 (5)	10100 (6)



Fire Risk Analysis – Input, methodology and uncertainty analysis

Marcus Andersson
Katarina Wadensten

Abstract

In many buildings that are being designed today ordinary fire codes can not be used to verify sufficient fire safety. Instead, various analytical methods are being used. For example, risk based design can be used. Using risk based design, the performance of the buildings fire safety is evaluated also with regards to possible failure of various technical systems. When performing risk based design it is necessary to use proper inputs in order to get valid results. These inputs can be difficult to estimate without extensive studies. Input uncertainties also produce uncertainties in the calculated results. In order to quantify these uncertainties an uncertainty analysis must be performed. Parameters used in fire risk analysis are therefore studied with consideration to these uncertainties and used in an example of a methodology to calculate risk in a probabilistic way.

Necessary inputs when performing risk based design consist of various types of information. The probabilities of failure for various technical systems need to be determined. Also, different parameters that affect the consequences of an occurred fire must be estimated. These are parameters that affect both the behavior of the fire and the evacuation process. Due to lack of information and statistics, these parameters are often assigned with highly uncertain values and this affects the quality of the results. Also, this makes it difficult to compare the results of different analysis due to differences in input and furthermore this problem makes it complicated to compare different design strategies in a just way.

Among others, the following parameters have been analyzed thoroughly:

- Fire frequencies for various occupancies
- Fire growth rate
- Probabilities of failure of various technical systems such as fire and evacuation alarm and sprinkler systems
- People densities and distributions for various occupancies
- Pre-movement time for various occupancies and alarm systems
- Exit flow rates, walking speeds and choice of exit for evacuating people

In addition to the study of input parameters, a methodology using Monte Carlo-analysis is used for risk analysis calculations. The risk analysis is based on an event tree and a consequence analysis in which calculations of the number of people exposed to untenable and lethal conditions due to the fire are made. The results are presented as risk curves and expected mean risk expressed in number of people exposed per year. With inputs given as probability distributions, the results can be presented with an interval.

The methodology is used carrying out an example where the studied parameters are used. In the example, different design strategies are analyzed and compared, and risk curves and expected mean risk are calculated for the different designs. The results of the risk profile calculations are exemplified in figures 1 and 2.

In conclusion, the experience of using a probabilistic approach in fire risk analysis is that the results have a higher validity compared to a deterministic analysis since a greater number of input and output cases are studied. This also facilitates a just comparison of different design cases. Furthermore, the problem with deterministic analysis displaying different results for the same case due to different choices of input is limited.

It is also clear that a probabilistic approach is possible to use to reduce and display uncertainties in the results without this leading to an unreasonable amount of work. It is also the opinion of the authors that using a probabilistic approach has great benefits as a design tool and produces more information as a basis of design decisions.

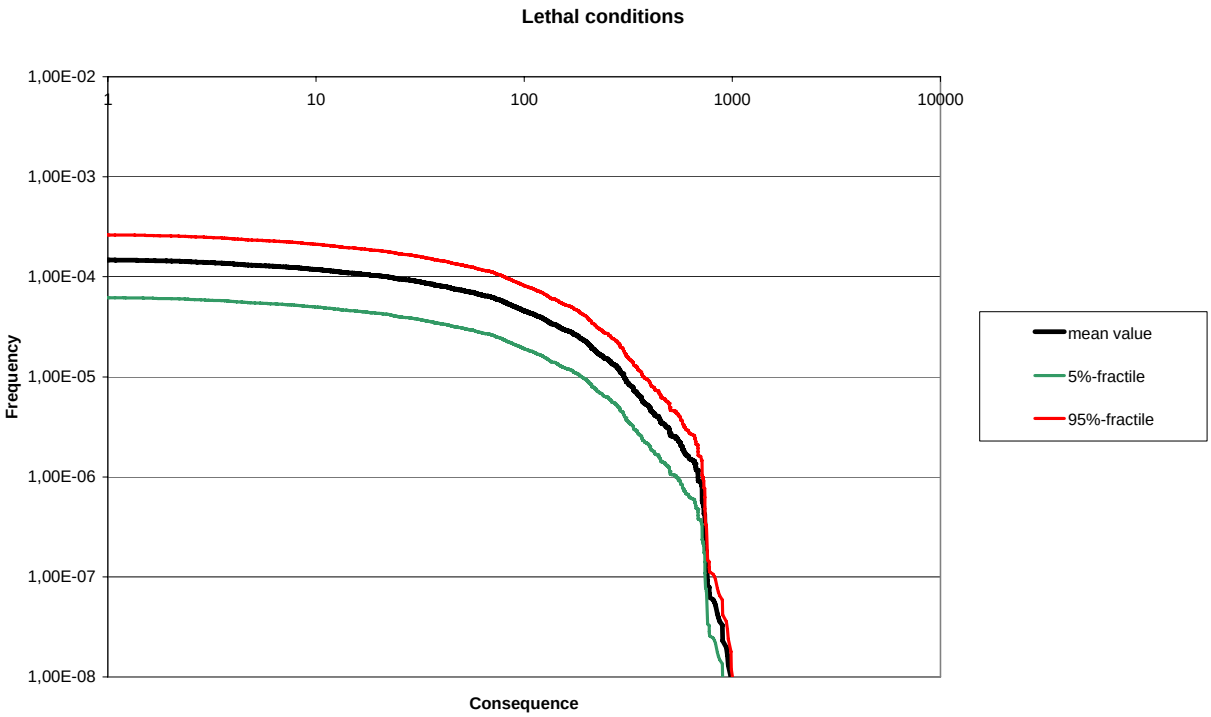


Figure 1, Risk curve displaying number of people exposed to lethal conditions for a sprinkled design case

When comparing this design strategy with others used in the example, the following results occur.

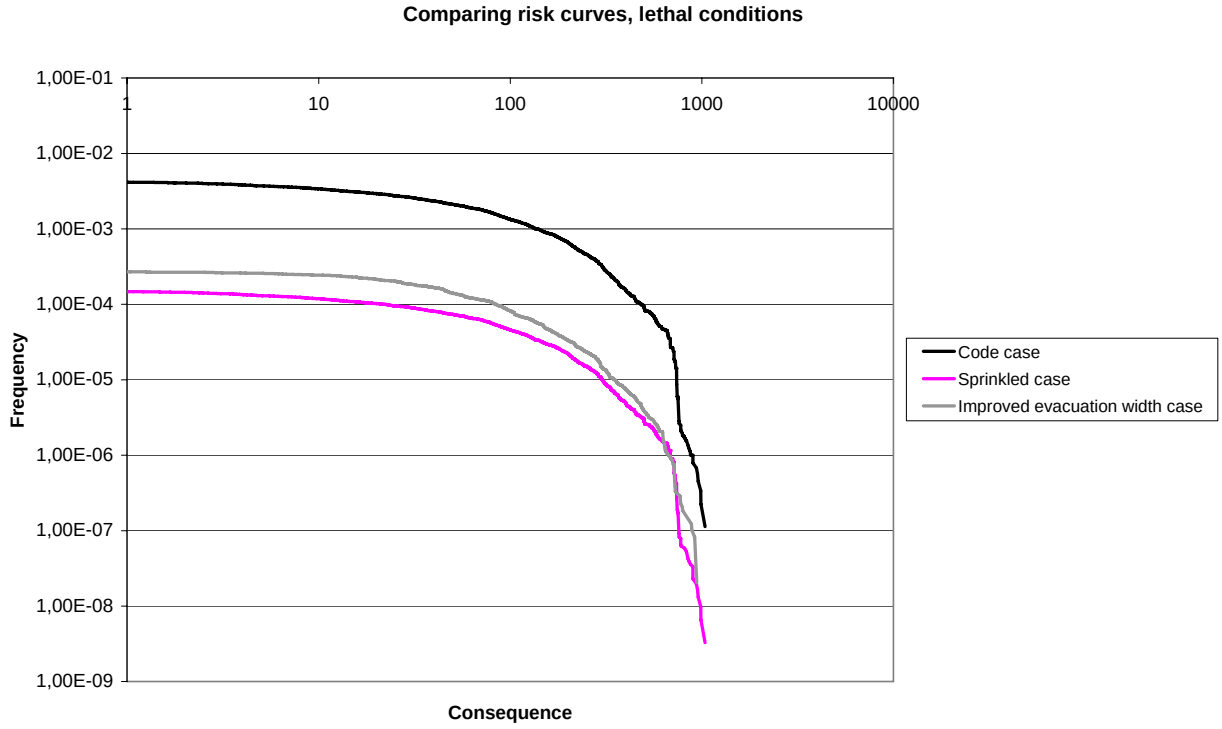


Figure 2, Risk curves comparing different design strategies

Quantitative Risk Analysis Procedure for the Fire Evacuation of a Road Tunnel – An illustrative example

Mattias Persson

This report presents a method for carrying out a quantitative risk analysis (QRA) for a unidirectional road tunnel. Due to the many recent tragedies in tunnels, the topic of tunnel safety has become very relevant, and more resources are being spent to improve the safety levels in tunnels. The methodology presented is a good tool for performing initial estimations of the risk level in a certain tunnel.

A brief description of the different levels of a risk analysis is include to give the reader background information about what is included and how detailed analysis on different levels should be. Analyses ranging from a qualitative to a quantitative analysis are discussed and the advantages of performing a quantitative analysis are made clear. It is necessary to have some sort of standard procedure when caring out a QRA this in order to get a result that is as subjective as possible.

Since every tunnel is different it is important to describe the tunnel that is being analyzed. Considerations to existing safety systems should be a natural part of the analysis. The methodology has been applied to an imaginary tunnel that has been defined in the report. Based on the tunnel description and the vehicles that use the tunnel, representative scenarios have been developed. Accident scenarios involving the following vehicles have been considered in the illustrative example.

- Car
- Heavy Goods Vehicle (HGV)
- Gasoline transport
- Propane transport
- TNT (explosive) transport

The frequency per year of each scenario occurring has been determined. In order to determine the frequency per year for the hazardous goods transports (gasoline, propane and TNT) the Swedish VTI model has been used. An uncertainty analysis has been carried out using various distributions for the input data in the frequency calculations. This results in a distribution of the final frequencies, which gives a good idea of the great variation in the results. This also shows the importance of being able to interpret the final results correctly, that is to say that the results should not be viewed as being absolute values but should instead be used as an indicator, to show if the level of risk is acceptable and if not where and how the available resources should be spent.

The estimated number of casualties for each scenario has also been determined. For the scenarios where design fires have been assigned, a model based on the Fractional Effective Dose has been used. In this model consideration is taken to the different toxicants that are present in the smoke that is generated by the various design fires and the effect they have on the escaping people. By assigning critical values, the model has been used to calculate how far people initiating from different areas in the tunnel can proceed before they are subjected to critical conditions. Based on these calculations the amount of casualties has been calculated. Consideration has also been taken to the direct radiation from the flames and the effect it has on the people it the direct vicinity of the fire. Due to the lack of knowledge of the phenomena Vapor Cloud Explosions (VCE), BLEVES and Flash fires certain assumptions have been made when determining the amount of casualties for these scenarios. At last the effect a pressure wave resulting from a TNT explosion in a tunnel has on humans has been calculated.

A separate evacuation analysis has been performed. Initially the amount of people in the tunnel has been determined using a simple queue model. Thereafter the time until people have evacuated different areas of the tunnel has been calculated using predetermined premovement times and set walking rates.

Having determined the frequencies and consequences (in terms of number of casualties) the final result has been illustrated using an F/N curve. Here the acquired F/N curve can be compared with set risk acceptance criteria, and the results can be viewed as acceptable,

unacceptable or acceptable given certain modifications or risk reducing procedures.

Finally certain safety systems are evaluated closer, a description of the safety system as well has how it can potentially affect the result when performing a quantitative risk analysis according to the described methodology is discussed. The safety systems that are discussed are; smoke ventilation systems, fixed suppression systems and a tunnel safety management system (SMS).

Evaluation of Fire Risks Onboard HMS Visby

Mikael Andersson
Arben Krasniqi

Abstract
The aim of the project was to evaluate fire risks onboard the Swedish stealth naval vessel Visby. By means of quantitative risk analysis methods including uncertainty analysis with Monte Carlo simulation together with zone model fire simulations, the risk, expressed as probability of component damage, was assessed.

Introduction

The article summarizes a project that represents the authors' final thesis for degrees in Bachelor of Science in Fire Safety Engineering and Master of Science in Risk Management and Safety Engineering.

The Swedish navy has ordered five crafts of the Visby class coast corvettes with the latest stealth technology, from Kockums AB. They are manufactured in a composite material, which provides many technological and marine tactical benefits, but it possess different attributes under fire load than traditional choices of material for building navy ships. The project presented here was founded by The Swedish Defense Material Administration, FMV, and is an evaluation of the risk conditions with reference to the first vessel considering fire risks as well as a discussion in relation to the use of the thesis's results in the risk management process of the Swedish Armed Forces.

HMS Visby

HMS Visby, figure 1,, is a unique and highly hydrodynamic design featuring the latest in stealth technologies.

Figure 1, HMS Visby

She is a fast attack Corvette with minimal signature and noise level, even at high speeds. All weapons that on board are able to fold down inside the hull, giving it more stealth capability, see technical data below in table 1.

The Visby Class corvette Technical data	
Overall length	73 m
Beam	10.4 m
Displacement	600 tones (fully equipped)
Draught	2.4 m
Crew	43
Hull material	Sandwich construction carbon fibre reinforced plastic (CFRP)
High-speed machinery	4 gas turbines, total rating 16 000 kW
Low-speed machinery	2 diesel engines, total rating 2600 kW
Propulsion	2 waterjet propulsors
Speed	>35 knot

Table 1, Technical data

Specific fire safety problems onboard

First, HMS Visby is a so called High Speed Craft, constructed of a special laminated material that makes her light, fast and invisible on radar. However the material has completely different fire and heat transfer characteristics than the traditional ship building material, steel. With an external heat flux, as from a room fire, the laminate itself will sustain a fire producing a lot of black smoke and of course, heat. Also, the material soon becomes fragile and looses all strength when the core is exposed to temperatures of about 90 °C. Addi-

tionally it is both costly and difficult to repair the ship, since the whole ship consists of a load supporting matrix of laminate walls and decks. Consequently the material considerably changes the normal fire safety aspects that apply on a marine vessel.

Method

The key method used is presented below in figure 2. The first part of the work was based on a risk identification method, so called preliminary hazard analysis, which was carried out in close cooperation with associated parties, Kockums AB, FMV and the Swedish Marine. Through this initial analysis could the fire

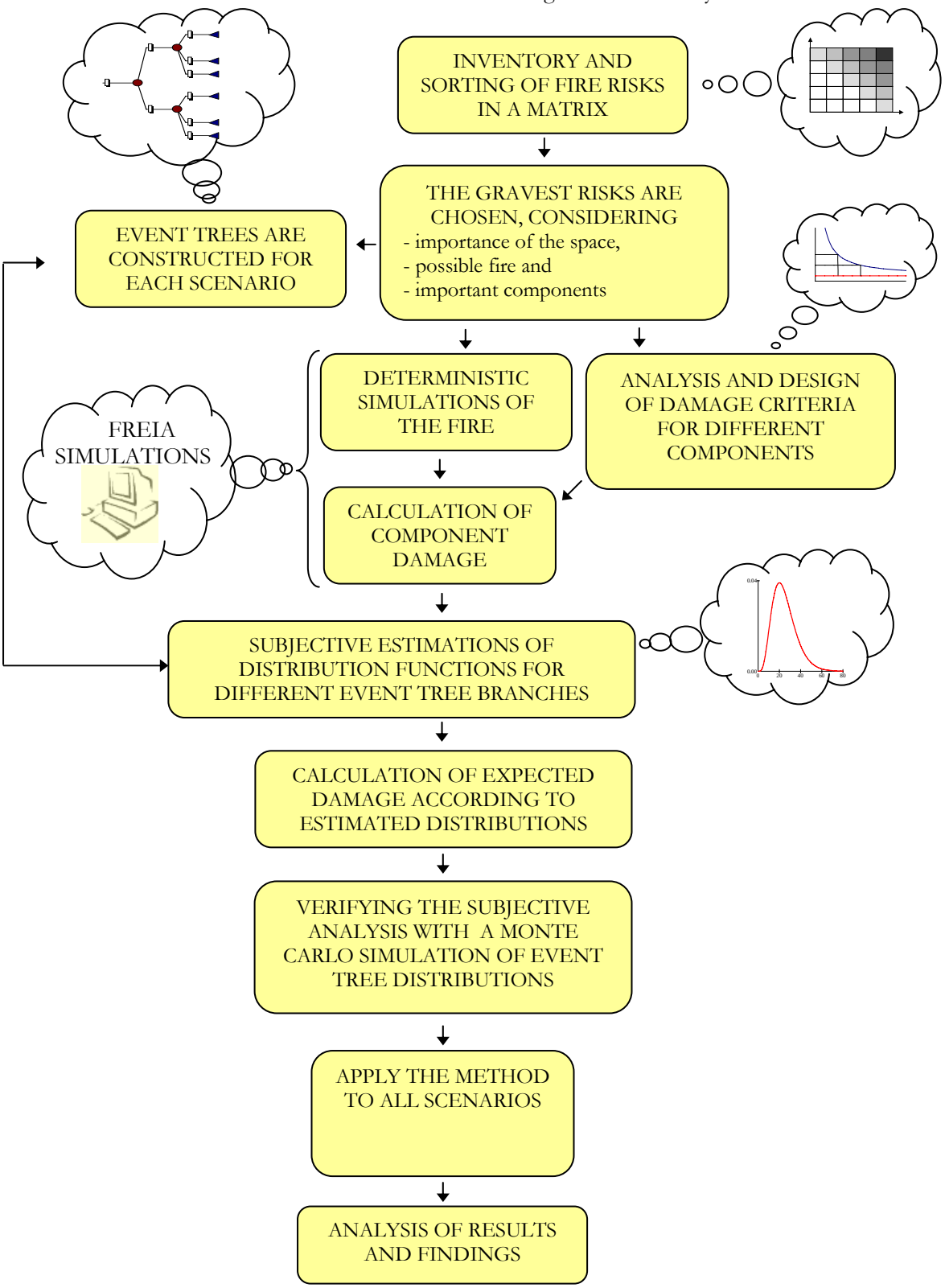


***Figure 5: M*ethodology overview**

related risks onboard Visby be identified and roughly estimated. By systematical use of these risks, and by arranging them in a matrix, an overview of the fire risk situation could be presented, from which further dealing and deeper evaluation of the gravest risks could be made.

The approach of the more thoroughgoing investigation consisted of two main alignments:

1) The greater part of the work was statistical calculations of expected values of component damage based on deterministic simulations by use of a two zone model, FREIA. A damage criterion was created from heat transfer tests, computer simulations, reference material 0, 0. Three types of components were used, (1) human skin, (2) different types of electrical cables that represented electrical and steering systems and (3) the laminate material of the ship itself.
2) In addition an assessment of smoke temperatures and heat radiation in a cabin by CFD-modeling was also carried out.

The analysis is limited to assessment of pure fire risks onboard Visby and only in peacetime, since war actions and weapon induced damage changes the risk situation severely and also alters the acceptance criteria. Furthermore the study is also limited to analyzing personnel safety and operability of vessel, while only discussions regarding economical consequences are made and environmental issues are completely left out. Design and function of extinguishing, ventilation or alarm systems have not been evaluated although their impact on fire behavior is considered.

Results

The work shows a relatively low fire related risk level onboard Visby, even though limited damage is expected from a fire regardless of the function of extinguishing systems. The reliance on several active systems and correct human action in high stress situations is considerable, which constitutes a risk of its own. Additionally, the thesis demonstrates that some fire safety details remain to be analyzed more thoroughly, since some functions are not optimized. If a fire safety system, for any reason, would fail the consequences of a fire would be substantial in forms of personnel safety, ship's operability and economical damage. Thus, the importance of a well functioning training, accident/incident follow up and maintenance organization is emphasized.

Following are results and conclusions presented for each scenario:

Men's cabin
As it is stated earlier the risk level is highly dependent on the reliability of the technical systems as activation and suppression systems. The CFD simulation shows that ventilation will not manage to evacuate the hot smoke and gases. The time to reaching critical conditions is less than a minute which is considered a very short. A fast functional detection system is the most important factor for saving lives in a case of fire.

Electrical apparatus rooms
These two rooms are similar to each other and the consequences of the same nature though consequences affect different systems onboard HMS Visby among which are steering and control systems and so one. In these two cases, the result shows that there might be a need for fast suppression. Further analysis should be done whether a suppression system would be a reasonable investment knowing the serious level of the consequences in a case of fire.

Cargo deck
The probability that a pool fire will start and evolve in this compartment is small because there are different fire prevention systems such as draining and suppression system. But the consequences could be fatal because of the cargo in this area such as torpedoes and other ammunition. The fact that the activation of the suppression system is to be maneuvered manually shows a need for a well trained organization for optimal decision making in case of firefighting.

Engine rooms
Engine rooms onboard HMS Visby are equipped with both detection and suppression systems. The suppression system is to be activated manually as it is in cargo deck which prolongs the activation and later suppression time. The level of consequences of a fire in these rooms is highly dependable on the reliability of both suppression system and human factor (firefighting organization).

Combat control center and steering deck
Fire in these compartments would be small due to the limited amount of fuel. But consequences because of non-thermal damage such as smoke on electronics are substantial. The fire safety in both rooms is generally on an acceptable level, since the spaces are always manned during operations. Devices for manual suppression are placed in this room but this would not help when HMS Visby is docked and these areas are not guarded. A further analysis of installing of an automatic suppression system should be done.

References

Andersson M., Krasniqi A., *Utvärdering av brandrisker på HMS Visby*, Report 5084, Department of Fire Safety Engineering, Lund University, 2001, 200 pages. (Swedish)

Andersson P., Evaluation and Mitigation of Industrial Fire Hazards, Brandteknik, Report TVBB-1015, Department of Fire Safety Engineering, Lund University, Lund 2000, ISSN 1102-8246

http://www.kockums.se/SurfaceVessels/visby.html (2002-07-21)

Society of Fire Protection Engineers The SFPE Handbook of Fire Protection Engineering 1995 ISBN 0-87765-354-2, 2nd Edition

Supplier Selection When Considering Risks for Disturbances in the Inbound Flow to Scania – A model for supply chain risk management

Fredrik Finnman

Abstract

This article is a result of a Master Thesis in Engineering Logistics at the MSc programme in Risk Management and Safety Engineering, Lund Institute of Technology. The thesis was written in co-operation with the truck manufacturer Scania. The aim was, with Scanias supplier situation as a base, to create a model for supply chain risk management to be used in the supplier selection process when evaluating suppliers for the inbound material flow. In continuously using such a model the frequency of disturbances can be decreased and, as a result, the costs can be reduced. The basis of the model consists of the risk management process: risk analysis, risk evaluation and risk reduction/control. In practice six interacting parts, from scope definition to decision-making, creates the risk management process. Two practical tools, based on decision-tree analysis (preliminary hazard analysis) and multiple attribute decision-making (supplier ranking), constitutes the essence of the model. Main conclusions of the thesis is that the model has an important task to fulfil in the supplier selection process and that it can add substantial value to the procurement process in most companies.

Introduction

During the last decade outsourcing has become an increasing trend in industrial production. This creates an increased dependence upon suppliers, especially when procurement of a strategic or bottleneck product is made from a single source, so called single sourcing. Furthermore globalization of world economy creates new procurement opportunities with an increasing number of potential suppliers in new markets. But this, in some cases, also comes with an increased complexity in the supply chain. These factors induce increased risks of disruption in the inbound flow to most companies and therefore call for supply chain risk management.

Not only has higher cost-awareness made companies outsource non-core production, but they have also focused on decreasing production-costs internally. This has been made by increasing production efficiency and decreasing lead-times through Japanese production philosophies such as, for example, just-in-time and lean production. Time- and resource optimized production has decreased time-marginals and buffer volumes which in turn creates an increased risk for disturbances and disruptions in the supply chain.

One company affected by these risks is Scania. Today the company mainly purchases it's components from the normal production markets, Europe and Latin America. But there is an increased attention to new procurement markets outside these. This implies a larger selection of suppliers but also an increased possibility to diminish costs. New suppliers in these markets can induce a more complex logistics chain. Lead times increase and the transport pipeline become longer which in most cases also increase the risk of disturbances. Scania is aware of these risks and is working hard with increased risk awareness in the procurement organization, but they still lack a holistic and proactive way of looking at risks as a natural part of the supplier selection process. There are three categories of problems that Scania is facing: the supplier selection, risks for disturbances in the upstream material-flow and supply chain risk management.

Method

The first part of the project consisted mainly of literature studies in the fields of supply chain management, technological risk management and purchasing. This was to create a theoretical frame of reference on which to build the model. The selection of books and articles that discuss risks in the supply chain was found to be limited. To counteract this other risk related literature was consulted. The main source of information was the databases, primarily Lovisa and Elin, at the library at Lund University. Hence, I also

found interesting material in literature used in courses at Lund Institute of Technology.

When making the empirical studies, interviews were the main method used. These were conducted both in groups and individually with key personnel at Scania. Interviews were not always formally recorded due to their informal structure. Continuously through the process feedback was collected from Scania to revise the model.

What is Supply Chain Risk Management?

Supply chains of today that comprise hundreds or in some cases thousands of companies, extending over several tiers, present numerous risks. Broadly these risks can be classified into two categories: risks arising from within the supply chain and risks external to it.

Risks within the supply chain arise from interaction between constituent organizations across the supply chain. It is caused by sub-optimal interaction and co-operation between the entities along the chain. Such risks may be the result of lack of "ownership", self-imposed "chaos", just-in-time practices and inaccurate forecasts. External risks arise from interactions between the supply chain and its environment. Such interactions include disruptions caused by strikes, terrorism and natural catastrophes.

Together, supply chain risks and risks external to it, impact the vulnerability of the supply chain. Simultaneous occurrence of both risks and interactions between them intensifies the damage to the supply chain. With this in mind a reasonable definition of supply chain vulnerability would be:

"*an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain*" . /1/

Supply chain risk management aim at identifying potential risks and implementing appropriate actions to diminish those risks. Thus it can be defined as:

"the identification and management of risks within the supply chain and risks external to it through a coordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole". /2/

Developing the Model

Four goals guided the construction of the model: creation of an instrument for risk management in the procurement process, increased risk awareness in the purchasing process, creation of a basis for supplier selection decision and simplicity for the user. Emphasis was put on increasing the purchasers risk awareness and simplicity.

The basis for the model consists of the three parts of the risk management process: risk analysis, risk evaluation and risk reduction/control (figure 1).

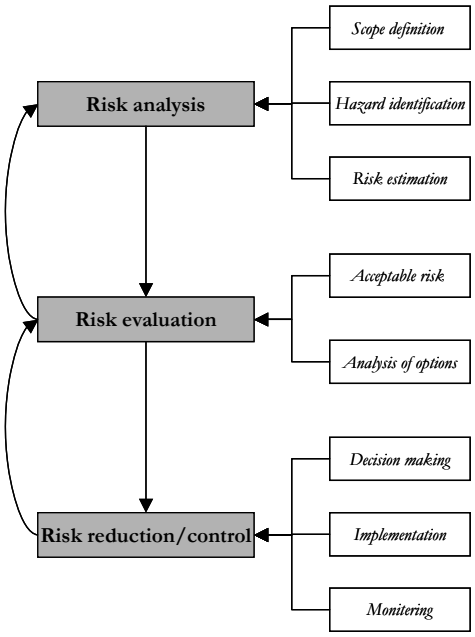


Figure 1, Basic model. /3/

Scope definition
Boundaries of the study are confined upstream by the inbound flow to the suppliers production unit and downstream by the off-loading dock at the Scania production unit. This area include tiers upstream the supplier and the transport chain between the supplier and Scania.

Hazard identification
Hazard identification can be conducted in a number of ways. In this study a purely qualitative search for disturbance risks was made. Through the use of key words risk parameters were derived. Identified parameters where then divided into three priority groups based on their influence on supply chain vulnerability.

Priority group A consists of the following parameters:

1. Strategic supplier; due to the suppliers unique knowledge and/or strong ties to Scania it is hard to replace
2. Strategic-/bottleneck product; products that if interrupted causes disruptions or disturbances to Scania
3. Logistics complexity; poor distribution networks and complex transport routes causes increased risks

This group constitutes the basis for risk estimation in the next section.

In group B a number of parameters was used for the risk evaluation (acceptable risk and analysis of options). These are:

1. Tool ownership; loss of production tools in the case of supplier running bankrupt
2. Supplier risk awareness
3. Supplier market strength; a strong supplier might prioritize other customers in a bottleneck situation
4. Insurance coverage; induces risk awareness and protection against bankruptcy
5. Production limitations; bottlenecks and changes in the production process might cause increased probability for disruption
6. Infrastructure; poor infrastructure between the supplier and Scania increases the logistics complexity
7. Catastrophic events; force majeure related occurrences like earthquakes and floodings

As stated above these parameters are included in the risk evaluation described in coming sections. Parameters in group C where not considered useful in the model but still constitute a source for identifying risks in the supply chain. These can be found in the thesis.

Risk estimation

To conduct the initial risk estimation a preliminary hazard analysis (PHA) method was used. The aim with PHA is to eliminate those suppliers that don't constitute a measurable risk to the supply chain. All other supplier options will undergo further analysis in the risk evaluation process (coming sections).

To estimate the risk a basic decision tree was used. Through the use of the risk parameters in priority group A, strategic supplier, strategic-/bottleneck product and logistics complexity, a level of risk is derived. There are three levels of risk, high, medium and low. Low risk means that the supplier can be chosen without any further analysis. High and medium risk suppliers must undergo the next step in the model.

Acceptable risk

Formation of the risk evaluation tool was based on a multi-attributive decision making (MADM) technique called analytical hierarchy process (AHP). MADM is basically a number of techniques that can be used to evaluate competing alternatives that are defined by multiple attributes. /4/

AHP is essentially the formalization of our intuitive understanding of a complex problem using a hierarchical structure. A hierarchy has at least three levels: focus or overall goal of the problem at the top, multiple criteria that define alternatives in the middle and competing alternatives at the bottom. Through pair wise comparison one can assign weights to the different attributes related to their contribution to the overall goal. I this case the overall goal is "best supplier".

The hierarchical structure consists of four levels beneath the overall goal (figure 2). Firstly attributes are divided into operative risks and business criteria. Operative risks comprises of risks internal and external to the supply chain. Internal risks are parameters 1 to 5 of group B in the hazard identification and the external are parameters 6 and 7. Business criteria are divided into quality, cost, design and product design change flexibility. Assigning weights to attributes is done as described above.

Analysis of options

There are mainly two alternatives suitable for the comparison of suppliers. A more complex method is to continue the pair wise comparison further down the hierarchy. That is to compare all attributes with each supplier. As level 4 comprises 11 attributes this takes some time. The recommended way is to use a simple index method. Suppliers are given a rate from one (very bad) to five (very good) for each of the attributes. The total index

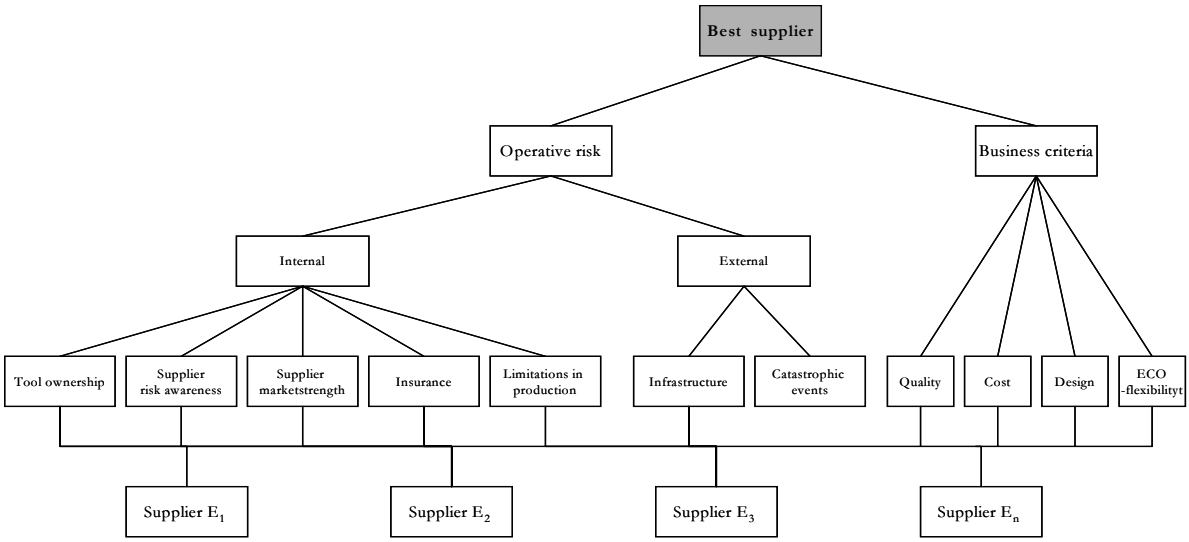


Figure 2: Supplier selection hierarchy

score is then computed by multiplying the comparable rating for each attribute by the importance weight assigned to the attribute. These are then summed and the sum constitute the index-value for that supplier.

When this has been done with all competing alternatives (suppliers) one receives a ranking list that reflects to what extent suppliers fulfils the overall goal "best supplier".

Decision-making
Decision-making is a complex process and comprises not only concrete parameters. One of the aims with this model is to deliver a basis for decision making for purchasers at Scania.

There are numerous decisions to reduce risk of current interest. Some examples of such decisions are presented below:

- Redesigning the product
- Choose other supplier
- Risk reducing measures
- In-house production

Together with the last steps, implementation and monitoring, this comprises the main part of risk management model. Hence the model can be defined as a tool used in an uncertain supplier

selection situation resulting in a basis for decision-making.

The Supply Chain Risk Management Model

In the sections above the principles for developing and using the model was described. On the next page a more pragmatic description is presented (figure 3). This picture represents the finished model for supply chain risk management. A more thorough description of the model and its practical use is found in the thesis (in Swedish). Vertical dotted arrows in the models middle level constitutes the appropriate working pattern when using the model.

The model as presented in figure 3, is ready for use in almost any supply chain. As it was originally constructed for the auto industry, use on other supply chains might create the need for modifications. But due to the flexible nature of the model this is not a major problem.

Conclusions

Supply chain vulnerability is without a doubt an increasing problem for many companies. This is partly a result of time- and resource optimized production, outsourcing and a globalized economy. Every day disturbances in the inbound flow occur at Scania, which in turn generates increased production costs. In the event of a disruption one also have to take into account goodwill losses.

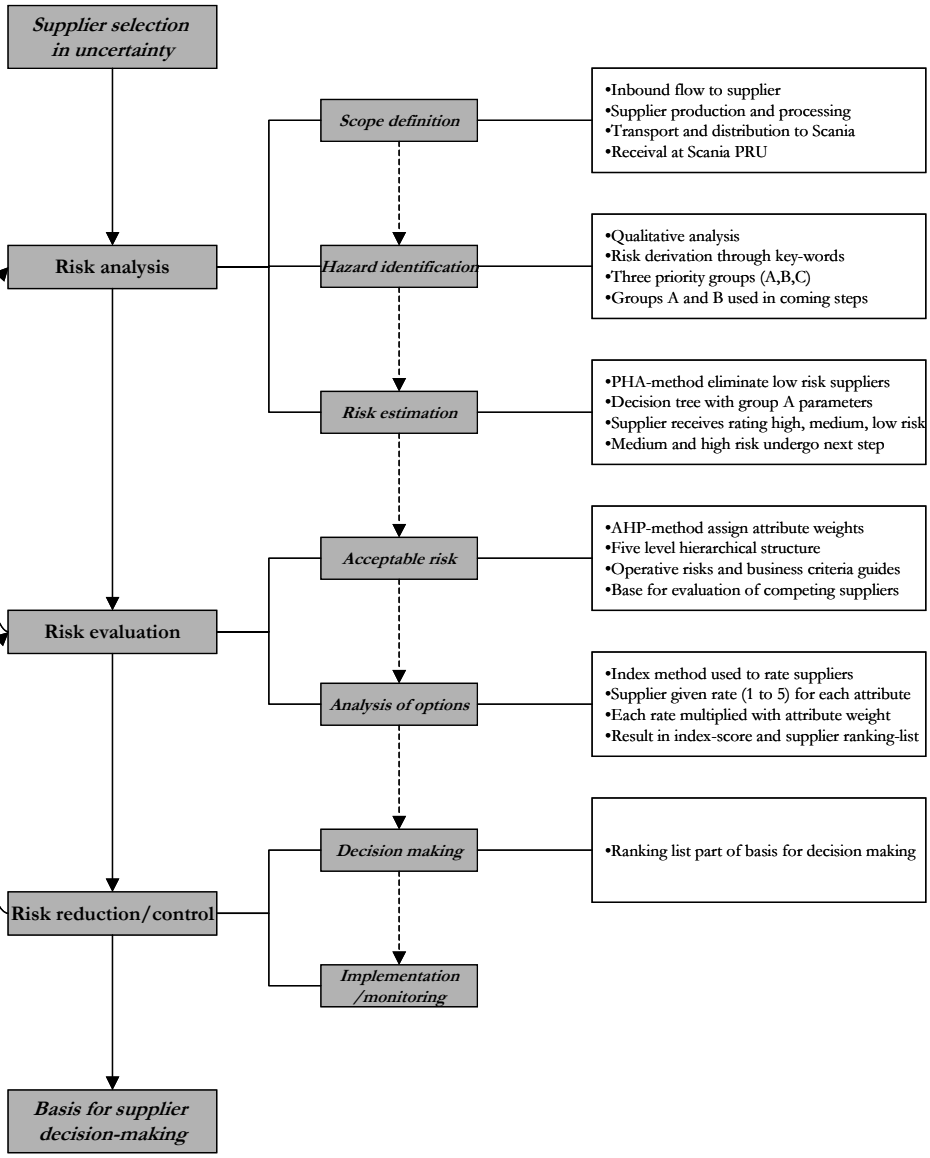


Figure 3: The Supply Chain Risk Management model

The risk management model presented in this article has an important task to fulfill in the supplier selection process. It can add substantial value to the procurement process in any company.

As a whole the model has certain limitation in its applicability to Scania. This is mainly a result of the low risk awareness among the purchasers, which makes it somewhat complex to handle.

However very positive feedback was given to the PHA-part (preliminary hazard analysis) of the model. A PHA like the one presented in this article can easily be used to create an increased attention to risk in the supplier selection process. Further the model contributes a great deal to the academic and industrial knowledge in supply chain risk management.

References

/1/ *Supply Chain Vulnerability* (2002). Cranfield University, School of Management. UK. (p. 2)
/2/ *Ibid*
/3/ International Electrotechnical Commission (IEC) (1995): *Risk analysis of technological systems.* Genéve.
/4/ Hwang & Yoon. (1995): *Multiple Attribute Decision Making – An Introduction.* Sage University Paper. USA (p. 2)

Assessment of the Frequency That a Damage Criterion Will Be Met as a Consequence of Fire – The BrandFeldt model

Anna Brand
Martina Feldt

Abstract

In the probabilistic safety analysis at nuclear power plants consideration isn't always taken to the fact that a fire can affect a component in an adjoining room to the fire. To take this aspect into consideration in safety analysis, a model has been developed, the BrandFeldt-model.

Risk analysis is one part of the risk management process. The risk analysis can be further divided in three levels, qualitative methods, semi-quantitative methods and quantitative methods. The qualitative methods are used to identify the most hazardous events, without ranking the events. In the semi-quantitative methods the relative hazards that are associated to the events are determined. The semi-quantitative methods thereby make it possible to assess the frequency and the consequences of an event. The quantitative methods are the most extensive in terms of quantifying the risk. The quantitative methods are separated in deterministic and probabilistic analysis. In the deterministic analysis the hazard is described in terms of consequences, while no consideration is taken to the frequency of the event. In the probabilistic analysis on the other hand the quantified risk is determined based on both the frequency and the consequences.

At nuclear power plants probabilistic safety analysis are conducted. In this analysis the common assumption is that all safety-related components are damaged in the room where the fire is initiated. A probabilistic safety analysis considers a component in an adjoining room to be affected only when flashover has occurred. The probability for the fire to spread is, in these cases, assumed to be equal to one. When a fire does not reach the flashover point, it is assumed that the fire does not affect the safety-related components in the adjoining room. There is proof, however, that fire can affect these safety-related components even though the fire is located in an adjoining room. The probabilistic safety analysis doesn't take into consideration the probability that a door may be open between the two rooms.

Since safety-related components in adjoining rooms can be affected by fire (heat radiation, increased temperature and smoke) without flashover occurring in the fire room the BrandFeldt-model was developed. The only considered connection between the two rooms is a door, which may be open or closed.

The BrandFeldt-model results in the frequency with which a component, placed in an adjoining room to the fire room, will reach predetermined damage criteria at one or more points of time. The BrandFeldt-model accounts for the frequency with which a fire will occur, the probability that the door between the adjoining rooms will be open, and the probability that the predetermined damage-criteria will be reached in the adjoining room (DOP-value; Damage Occurrence Probability value). The DOP value is estimated by means of a calculation program, which has been developed in this work. To illustrate the factors that influence the frequency in the BrandFeldt-model, an event-tree is modeled. By means of an event-tree the frequency with which an event will occur and the consequences of the event is obtained. The frequencies at different times can be compared to the companies accepted risk level and thereby give guidance on when measures to increase the companies safety is to be made.

For a schematic illustration of the BrandFeldt-model see figure 1.

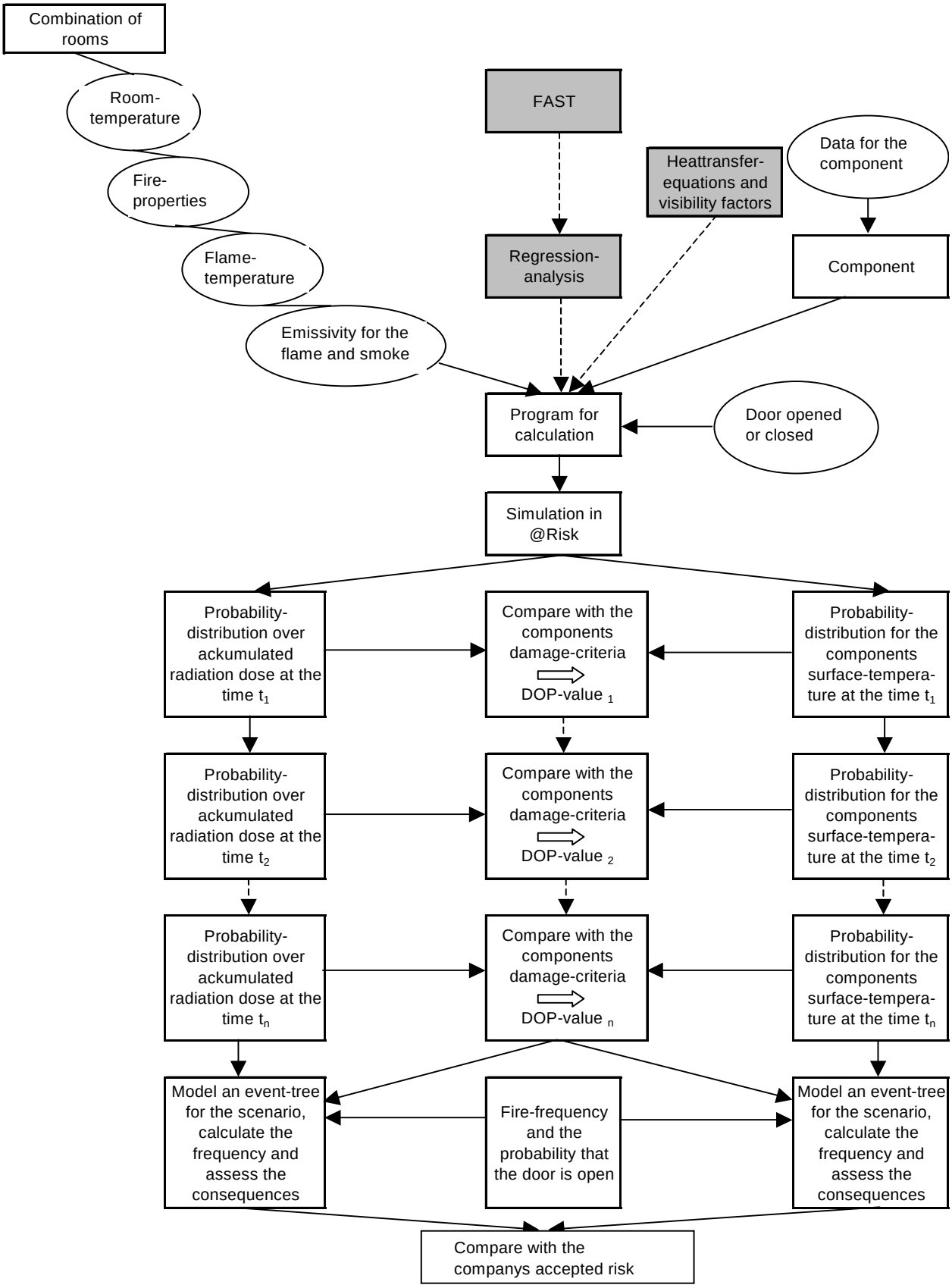


Figure 1, A schematic illustration on how to use the BrandFeldt-model.

The BrandFeldt-model can also be adjusted if other parameters are to be taken into consideration such as the function of fire detection and sprinkler systems. The model results should be compared to the accepted risk level of the company and provide recommendations to reduce the risk level when and where appropriate.

The DOP value is also to be used in a probabilistic safety analysis regardless of the occurrence of fire flashover. As a result, the DOP value can replace the current simplification in the probabilistic safety analysis (the probability equal to one when flashover occurs and equal to zero when flashover does not occur). By using the DOP value instead of the simplified assumptions of the traditional analysis, the results obtained are more accurate when applied to real situations.
The risk level may be underestimated by using traditional probabilistic safety analysis. Since no flashover occurred, the probability would be zero. This result would lead to a frequency of zero. The company's Board of Directors may thereby be mislead by the results to believe that no precautionary reductions in present risk level are necessary.

Solely the BrandFeldt-model cannot assess safety-related problems. A continuous and pre-emptive risk reduction program must therefore be implemented to maintain or reduce the present risk level.

Smoke Control Systems Aboard – A risk analysis of smoke control systems in accommodation spaces on passenger ships

Caroline Andersson
Daniel Säterborn

Background

Chapter II-2 in SOLAS, concerning the fire safety aboard ships, has been altered a number of times over the years. The many changes and adaptations made the regulations more difficult to apply. In 1991 it was decided to make a comprehensive review of chapter II-2. During this review it was discussed to include new regulations concerning smoke control on passenger ships. It was however decided that these requirements should be issued as a MSC circular instead, except a generalized requirement for smoke extraction in atriums. The purpose of this study is to evaluate the risk level combined with usage of smoke control systems aboard ships in order to provide further information to be used during the development of the circular.

The studies are presented in detail in the main report: "*Smoke Control Systems Aboard – a risk analysis off smoke control systems in accommodation spaces on passenger ships*" by Andersson, Caroline and Säterborn, Daniel. The work has been supervised by Techn. lic. Johan Wikman at the Swedish Maritime Administration and prof. Sven Erik Magnusson at the Department of Fire Safety Engineering in Lund.

Limitations

The three major limitations made in this study are:

- The study only comprises smoke control systems of the accommodation spaces in the object, meaning that high-risk areas like engine rooms and cargo decks have been left out. A separate analysis will have to be made for these areas.
- The study is focused on how smoke control systems affect the height of the smoke layer. The effect of smoke control systems on smoke temperature and radiation from the smoke to evacuating persons has not been evaluated.
- Sprinkler systems have been neglected. To be able to analyze the worst probable cases for a fire on a typical passenger ship, the fire suppressing / extinguishing effect of a water sprinkler was omitted.

The main report specifies more detailed information about the limitations and assumptions made.

Methodology

Analyzed objects
The base for this study is the *M/S Skåne*, a Ro/Ro-passenger vessel operating in the Baltic Sea. The vessel has been used as an input source for different conditions concerning geometry, fire load and configurations of the existing ventilation system.

Although *M/S Skåne* is a large ship, its public areas do not fully represent the range of possible variations in geometry that are becoming more and more common in modern passenger ships. The wish to be able to use geometries more representative for passenger vessels in general resulted in creating alternative geometry's based on the geometries of *M/S Skåne*. These geometries are said to be on the fictive ship *M/S Alternative*.

Risk Analysis
The semi-quantitative risk analysis method used to determine the worst probable scenarios is a method called PHA, or Preliminary Hazard Analysis. This type of analysis is mainly used as a first step to identify and estimate the possible hazards on a low-detail level in an existing structure. The purpose is to decide which hazards are in need of a more extensive analysis. This decision is based partly on the evaluated level of risk, i.e. probability and consequence. But it is also based on the location of the hazard since it is of interest to study how the location of a fire affects the final conditions like temperature,

smoke spread etc. In the latter the purpose is to give preference to scenarios that affect different parts of the ships accommodation spaces.

With consideration of location, three different scenarios were chosen to be objects for further analysis on M/S Skåne. The chosen fire scenarios are originating in a cabin, in a playroom for children by an arcade and in a cafeteria. These design fires have also been applied to M/S Alternative's geometries. All of the chosen scenarios have been further analyzed in computer simulations, as shown in Figure 1.

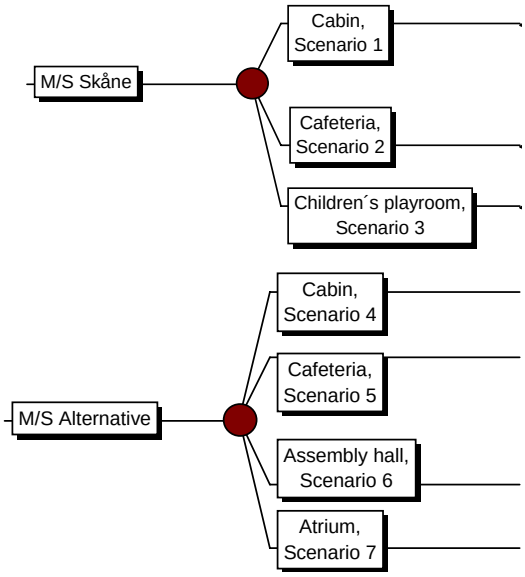


Figure 1, Event tree of fire scenarios on M/S Skåne and M/S Alternative.

The analysis was divided into two parts; *a quantitative risk analysis* and *a qualitative risk analysis*. The 7 different main scenarios, each with a number of sub-scenarios, were analyzed quantitatively with the computer model CFast to establish the required extraction capacities needed for a smoke control system. The results obtained were treated qualitatively by the means of using earlier research in the field as comparison and to discuss typical design solutions and risk factors. Finally conclusions were drawn and suggestions of further research given.

Complementary discussions on existing regulations and the introduction of performance based design were carried out. These discussions include the problem with setting a reasonable performance criterion for ships and the possibility of minimizing the fire load in the interior.

In the quantitative risk analysis three different ventilation configurations were added to each of the scenarios above, i.e. the ventilation system was:

- not activated, corresponding to an "emergency shut down" situation,
- activated with the capacity of the existing HVAC-system installed on M/S Skåne. (For scenarios on M/S Alternative a fictive existing capacity was used)
- activated with the capacity required to keep escape routes free from smoke to such an extent that the requirements of BBR are fulfilled.

The required capacities has for each scenario been compared to either the existing HVAC-system (Scenario 1-4) or to a fictive HVAC-system with a capacity of 12 replacements/hour (Scenario 5-7). The 12 repl./h capacity is a requirement for the air conditioning system to achieve comfortable conditions in public spaces. It means that the air in the entire space should be replaced 12 times per hour.

Conclusions

The main conclusion of this report is that a smoke control system, if correctly installed and used, improves the means of egress for the studied geometries. Pros and cons, economical risks and reliability of the system have to be individually analyzed and evaluated for each object. Further conclusions drawn from the results are listed in short below:

- **Fire in the cabin area:** It is necessary to install a separate smoke control system in the cabin area if not a higher capacity HVAC-system can be used. The exhaust should be placed in the corridor, preferably equally distributed. Supply air should as a rule be taken from the cabins existing supply air system and from adjacent stairway enclosures. Separate smoke extraction exhausts in each cabin is not recommended.

- **Fire in large public spaces:** If the HVAC-system in public areas is designed to provide 12 changes/h, the system can be said have enough

capacity to be used as a smoke control system. One neither needs more powerful fans or larger dimensions on the ducts since these are designed for large capacities anyway. However, additional upgrading concerning temperature resistance etc. has to be done.

- **Fire in the arcade – small public space:** The HVAC system installed in a public area cannot straight off be considered to have the required capacity of a purpose designed smoke control system. In contrast to the larger public spaces this typical example has a capacity that is far below the required. Hence, every system has to be designed on basis of a specific design fire. The recommended solution is to place the smoke extractions in the arcade and/or to limit the amount of fire load.

- **Fire in the atrium:** The existing regulations in SOLAS do not propose a reasonable solution for smoke control systems applicable to different atria structures. The applicability is limited since no consideration is taken to either the fire load or the requirement that the smoke layer should be kept at a safe level above deck in all evacuation routes, independent of their level in the atrium. The normal HVAC-system is in most of the cases studied barely sufficient and consequently it is relatively easy to upgrade it to meet the requirements of a smoke control system.

These conclusions are general for all scenarios:

- When designing a smoke control system one should use an acceptance criterion based on the smoke free height in a space, and not a criterion fixed to the volume of the space. The latter do not account for different fire load or the geometry of the specific space.

- An "emergency shut down" of the HVAC system, in the purpose to stop mitigation of smoke, does not necessarily improve the evacuation conditions. If one continues to run the system in the affected fire zone the conditions will become better, provided that recirculation of the extracted air is prevented by dampers. In other research this has been verified by full scale tests.

- Over-pressurization of adjoining fire zones hinders or hardens the smoke spread to these. This is especially important when evacuation has to take place through another fire zone causing doors to be held open. The over-pressurization can be managed with a "Smoke Control Strategy".

Natural Disasters Contribution to the Risk Situation in the European Union

Martin Andersson
Elin Kinnerberg

An overarching goal with the thesis has been to apply risk assessment as an instrument to examine natural disasters contribution to the risk situation in the European Union - today and in the future. By studying existing research in the area and by consulting experts, the needed information for this thesis has been collected. We have also attended in a field exercise concerning disasters.

The definition of disaster used is a situation when the local authorities are unable to handle the situation, and assistance is needed.

Natural disasters within the European Union have earlier been categorized in seven categories:

- Avalanches
- Hot humid Summer days
- Droughts
- Floods & tidal waves
- Earthquakes, volcanic eruptions & landslides
- Forest fires
- Tornados

This categorization has also been the position for our work. To be able to work with this wide approach, only the probability and consequence for the society has been regarded – causes and the characteristics of the natural disaster are left out in the analysis.

It is difficult to divide the conception risk into the two parts probability and consequence in the context of natural disasters. The initiating event for many natural disasters is out of human control when it happens, but the extent of the consequences is definitive a cause of human acts or lack of acts.

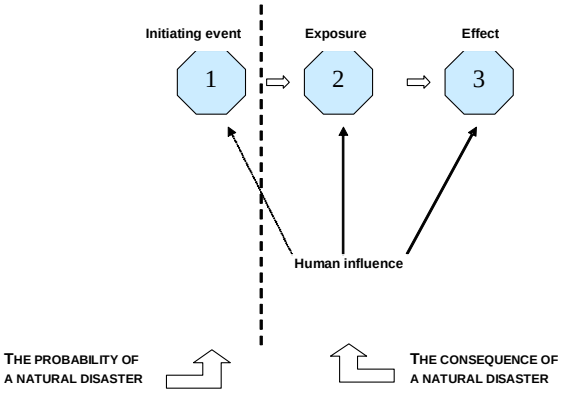


Figure 1

Risk can be defined in many different ways. The technical definition of risk is the sum of all conceivable scenarios' products of probability and consequences, i.e. the answer to the questions *what can happen?* and *how probable is it?*. The conception risk also includes other factors such as social, psychological and cultural aspects. Since the risks connected to natural disasters appear to show an interaction between natural and human activities, risk is considered also from a non-technical perspective in this report.

The thesis follows the structure of a risk assessment process. The risk analysis accounts both quantitative and qualitative aspects. The quantitative analysis is based on studies and work with statistics concerning natural disasters that have occurred within the European Union during the years 1975-2000. The qualitative analyze is based on studies concerning different factors that have an effect to the risk connected to natural disasters, and includes climate changes and the increasing vulnerability of the society.

The main result from the quantitative risk analysis is the fact of an increasing number of natural disasters within the European Union the last 25 years. The result also point at an increasing number of natural disasters also in the future.

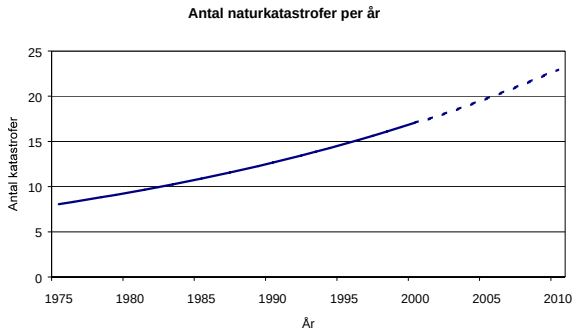


Figure 6, Prediction of number of natural disasters per year in the EU.

Northern Europe has been relatively spared from natural disasters. It's especially the countries in the south of Europe, around the Mediterranean, that's been stroked the most by natural disasters.

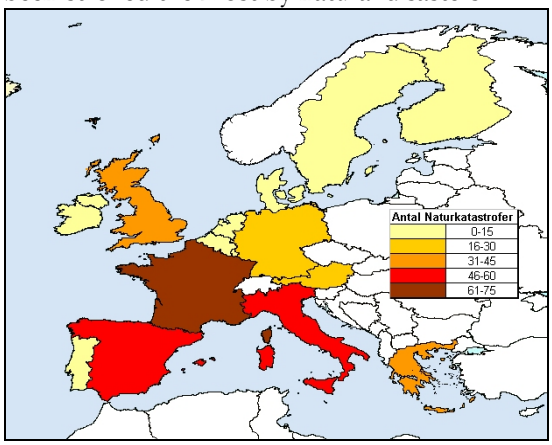


Figure 7

Floods & tidal waves and *Tornados* are the two categories of natural disasters that are the most common in the EU.

The frequency of natural disasters occurred is bigger in the total world compared to the EU, even with consideration for differences in area.

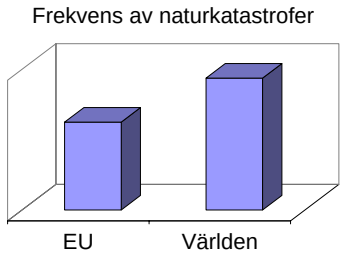


Figure 4

The relationship between EU, Europe and the whole world is 1:3:10 when EU counts to Europe and Europe to the world.

By average 400 people loose their lives per year in natural disasters. One can expect that it every thousand year will occur a natural disaster when 93 000 people will be killed.

Greece and Italy are the two countries where most people get killed in natural disasters.

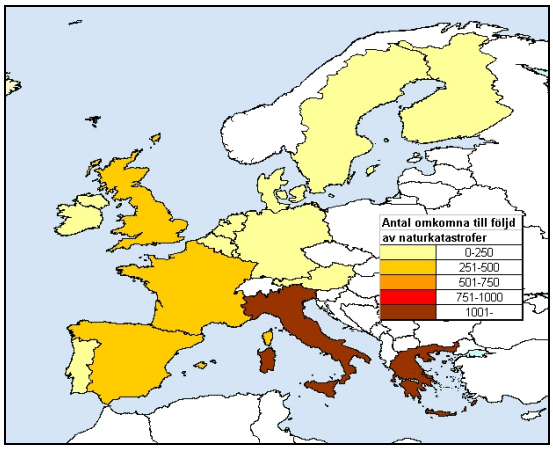


Figure 5

Earthquakes, volcanic eruptions & landslides and *hot humid summer days* are the categories of natural disasters that take most lives per occasion.

The result from the qualitative risk analysis also points at an increasing number of natural disasters in the future according to the climate change which contributes to a higher frequency of extreme weather situations. The increasing vulnerability of the society also contributes to an increasing risk connected to natural disasters in the future. Many functions in the society rely on complicated technology and the infrastructure and buildings are more and more complicated and complex. This contributes to higher consequences when a natural disaster occurs.

From the results in the risk analysis an evaluation of what the risk will mean to the European Union can be done. It is important to take in account that the prevention work regarding disasters and the response to disasters probably will be better in the future following the development of effective rescue techniques, i.e. fewer consequences. We have great possibilities to influence how the future will be.

It is also important to be aware of that there are many uncertainties involved in the result of the risk analysis. Since natural disasters are relatively rare, the result is based on limited amount of statistical data. When the risk is

evaluated it is also important to consider the phenomena risk aversion. People tend to accept many small accidents that cause small consequences compared to few big accidents that cause large consequences. It's very hard to state a specific level of acceptable risk in this context, but the risk can be compared to other risks in the society. During the period of 1975-2000, three times as many people were killed in natural disasters compared to aero plane accidents.

There are several measures that can be done to reduce the risk of a natural disaster before the event as well as after. It's important to adjust the measures to the future society and the "new" risk it will cause. One important measure is to improve the handling of serious situations and improve the exchange between the member states. Within the EU a "*Community Mechanism*" is being built up to strengthen the coordination of the member states civil protection efforts, provide assistance at emergencies etc.

During the period of carrying out this report, many different areas and questions have appeared, which haven't been possible to study within the limits of this project. It's a hope that this thesis can be used as a base to further studies in the area.

Fire Safety in High Rise Buildings

Emma Lindsten

Abstract

Today in our modern society we build more and more high rise buildings and several questions arise concerning the safety of people in high rise buildings. The thesis has been carried out to analyze different factors that can have affect on the fire safety in high rise buildings.

Several high rise buildings are being constructed in Sweden and some are in the planning phase. Turning Torso is going to be a 55 stories high resident building and it is being constructed in Malmö, Sweden.

Kista Science Tower is going to be an office building with 31 floors. The building is under construction and it will arise in Stockholm, Sweden. The fire protection in these buildings has been especially designed to make the building safe for the occupants.

The aspects regarding safety in high rise buildings are topical and the subject field is widely discussed, especially after the terrorist attack against World Trade Center in USA, the 11th of September, 2001.

The first question that needs to be answered is what buildings are high rise? The definition of a high rise building varies between different countries, but generally the term high rise applies to those buildings with floors above the reach of fire service equipment. When high rise buildings are considered, out of a safety perspective, it is possible to identify a number of problems that are associated with the height. They are described in the report and to receive a necessary level of safety for the people in high rise buildings these problems should be investigated, when the fire protection systems are designed. It is important that the safety of the fire service personnel as well as the safety of the others who stay in the building is taken into consideration. The level of safety in a building shouldn't be dependent on the number of floors. That could mean that some safety systems would be needed in high rise buildings.

The purpose of the thesis is to carry out a quantitative risk analysis for a high rise building that describes the risk level for the persons who stay in the building. This has been accomplished by using a method that takes risk sources associated with high rise buildings into consideration. A "what if? analysis", event trees and some fault trees have been used in the risk analysis.

The study is based on the conditions applied to Rumlaborg, which is a high rise building that NCC Teknik Bygg (Gothenburg, Sweden) is planning to construct in Jönköping, Sweden. This building is going to be a multi residential building consisting of 27 floors. The building consists in two parts that are connected by one stairway. This stairway is the only escape route available for the occupants.

In the risk analysis it is of importance to identify the problems that can occur when a potential fire starts in an apartment. The major problems are listed below:

- Changed evacuation situation for the residents
- Risk for vertical fire spread by the facade and windows
- Significant stack effect potential is present that can spread smoke through the building
- Changed ability for the rescue personnel to reach the fire
- Changed situation concerning the water supply for the fire service personnel during a fire attack

The analysis includes a study over different combination of fire protection systems in Rumlaborg. This is carried out to examine how the risk level can be influenced by different fire protection systems. The systems included are:

- Sprinkler
- Fire fighters lift
- Pressurization of shafts
- Smoke detector

The results of the risk analysis are presented by F/N curves, which show the risk level for the different combination of fire safety systems. To be able to make a valuation of the risk curves (F/N curves) an additional risk analysis has been carried out for a building that consists of eight floors. The conditions for this building correspond to the ones for Rumlaborg, except for the height and some of the fire protection systems. The building with eight floors does not have sprinklers, fire fighters lift or pressurization of shafts, but it has smoke detectors. This additional analysis makes it possible to compare the risk curves for different heights to see if the level of safety is dependent on the number of floors.

In a comparison between the buildings the analysis shows that the risk level in the high rise building can be reduced to a lower level than the one with eight floors, if it is provided with several fire protection systems (like smoke detectors in each department, sprinklers and fire fighters lift). But if the high building does not have sprinkler the risk level will be higher than the low building. The same situation will occur if the high building is constructed without a fire fighters lift.

High rise buildings distinguish themselves because of their heights. This can mean that the risk for an attack or sabotage increases (such as arson, bomb scare and bomb outrage). The quantitative risk analyses which have been carried out in the project take sabotage in form of arson into consideration. But the project does not include catastrophe scenarios such as bomb outrage. It is anyhow very important to be prepared for a total evacuation of all the people in a high rise building. Other wise it can occur problems with a fatal outcome. One problem is caused by the lack of escape routes. It can be crowded in the stairway and it can take a considerable time to evacuate all the people in the building. An additional problem with total evacuation in high rise building is the difficulty for the emergency staff to communicate with the occupants.

The Swedish legislation that controls the requirements for the fire protection in buildings is not suitable for high rise buildings. The requirement for a high rise building is to accomplish necessary level of safety for the people in the building. There are neither any guidelines nor any recommendations on how to fulfill this requirement and the level of safety is not specified. Therefore the report includes an international study of the regulation in some countries that have great experience and knowledge of fire protection systems in high rise buildings. The investigation is based on interviews with representatives from England, Australia, USA and Hong Kong. To sum up the countries require sprinkler, fire fighters lift, fire alarm system, two escape routes and possibility for the fire service personnel to communicate with evacuating people, in high rise buildings.

Risk Analysis of the Oil Depot Lucerna in Västervik

Thomas Bjerke
Jens Christiansson

The oil depot in Västervik is owned by OK-Q8 AB and has a yearly trade of 120 000 metric tons diesel oil and petrol. This amount is expected to rise considerably in the near future, which increases the need of a risk analysis to be carried out on the establishment. A lot of resources are spent on the safety work at the oil depot, which is classified as an establishment of § 43.

The establishment is one of the most modern oil depot in Sweden and the employees are relatively well aware of the risks that exist and actively try to prevent accidents from happening. Only authorized personnel can load the products from the tanks and the loading procedures are well worked in. The Emergency Centres (SMC) equipment is available, however it takes about 4½ hours before it is in the area.

This analysis identifies and estimates the risks in areas of security, health and environment, which are connected to the activity at the oil depot Lucerna in Västervik. The main area that has been analyzed is the security and the risks that affect the public.

Annually the oil depot deals with very large amounts of flammable fluids in shape of petroleum products. Potential accidents that can happen at the oil depot are somehow connected with petroleum products. From statistical information and experiences of accidents on similar establishments various accident scenarios have been produced:

- Overfill at loading place
- Overfill of tank
- Discharge of ammonia from the recycling of petrol gas
- Leakage on the pipeline
- Petrol truck accident

These credible scenarios have been the basis for the risk calculations, individual and societal, which could potentially affect the public in Västervik. In the scenarios where there is a present individual and societal risk, uncertainty analyses have been done to form an opinion of the spread and uncertainties in the results. The effects on the public of smoke from a tank fire have not been taken into consideration in the societal risk because of the complexity of the spread of toxic substances in an outdoor environment. The health hazards connected with smoke spread are however discussed qualitative in this investigation.

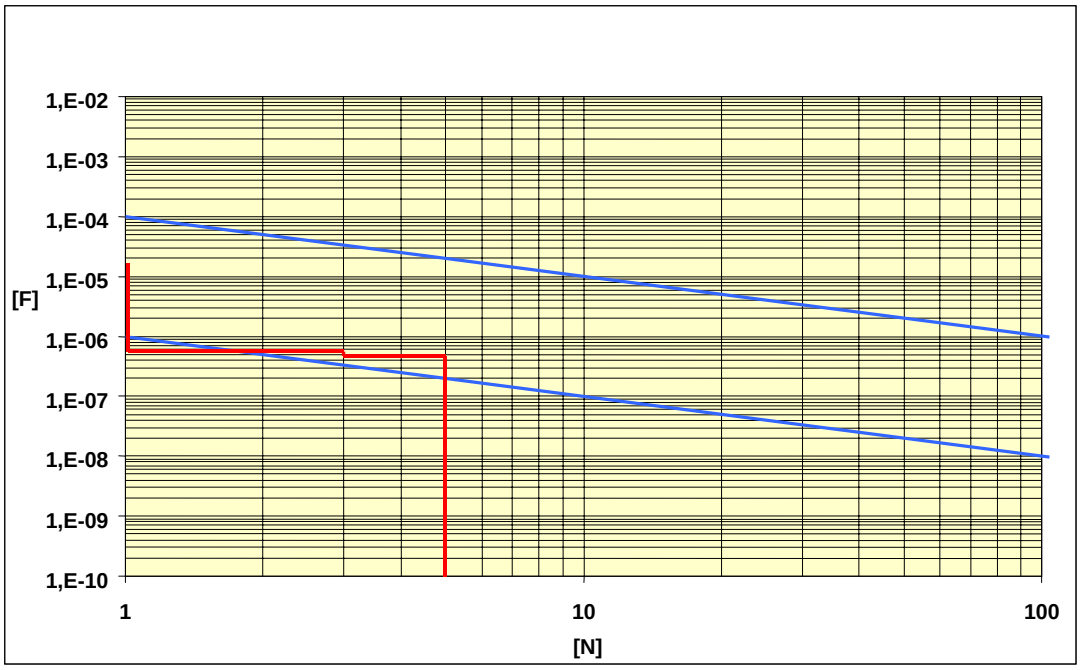


Figure 1, The societal risk present at the oil depot in Västervik.

We consider that the activity at the oil depot and its surroundings do not charge the public in Västervik with too high a level of societal risk, despite the fact that the calculations show some high levels of societal risk. An interesting observation is that non of the accident scenarios where the actual accident occurs on the oil depot grounds have an affect on the public (third person). The accidents that will have the greatest consequence to third person occur mainly during transportation of petroleum products by petrol truck from the oil depot. Here more responsibility should be applied to the local authority and Teknisk Service, whose task is to make sure that the traffic runs safe and smooth. A new driveway to Västervik from the south, where the majority of traffic with hazardous goods can go, had been the most efficient measure to reduce the societal risk.

When a risk analysis on an oil depot that is part of the OK-Q8 AB concern has to be carried out, the standard procedure is to use the SPI (Statens Petroleum Institut) model for risk analysis. This model only covers risks for property damage and production disturbances. The greatest weakness in the SPI model for risk analysis is the lack of a quantitative estimate for the societal risk, which is done in this report. However, we consider that a quantitative risk analyses should always be complemented with some sort of qualitative discussion/analysis.

The result from this report will support the rescue services continued work with rescue plans for the establishment. By using the same analysis structure as in this report, it can, after adjustment to each specific oil depot, be used on similar establishment.

Risk Analysis of Transport of Hazardous Material in the County of Stockholm

Patrik Dahlberg
Daniel Maria

Introduction

Transportations of dangerous goods are necessary for the society, in the same time as they constitute a risk. An accident where a transport of dangerous goods is involved could generate a release of dangerous substances. This could have a negative impact on the surrounding environment and people.

This study covers the dangerous goods transportations on railway and roads within the region RSN. The aim of the study has been to create a general method for the calculation of risks associated with the transportation of dangerous goods. The goal of this study has been to perform individual and societal risk calculations on particular locations, called hot spots, with help of present statistical data and information. Further more the methods applicability and signification in the risk management process have been illustrated. A discussion about the law's interpretation and applicability in the process of risk management has also been driven.

The study covers a large geographic area, which is approximately 4000 km2. Consequently to accomplish the study one must make several delimitations:

- The study has only regarded the transportations by road and railroad.
- The study does not considerate the impact on buildings and fauna that the release of dangerous substances have.
- The calculations for the release of a dangerous substance are based on the assumption that the weather always has the D stability class and the wind velocity is always 4 m/s. This assumption is base on the fact that these parameters are most likely to occur in the region.
- The calculation models for risk-distances and risk-areas are based on assumptions and delimitations made on sizes of holes, type of release, etc. Therefore the result of these calculations must not be regarded as the absolute truth but only as rough estimations.
- Goods vehicles and cistern wagons are custom adjusted, thus there is no standard for those. The sizes of the cisterns and tanks have been chosen as a mean value from known constructions.
- The study does not regard the transportations of mixed cargos. The amount of transported goods has been calculated from chosen tank-sizes and the SRV's survey on the goods flows within the region.

The hot spot conception

A hot spot is defined as a place with a high frequency of accidents and there severe consequences for the surroundings from an eventual release of a dangerous substance can occur.

Studying existing statistic data of transportation flows within the region and accidents related to the transportation of dangerous goods has been used as a method for the identification of hot spots. The material covering the accident- statistics has been used for the calculation of likelihood and frequencies of an accident within the region. As a complement to this work an inquiry about which places are specially affected by accidents or which places are particular sensitive in the event of an accident with dangerous goods, has been sent to all fire departments within the region. Further more interviews with key persons in the work area of dangerous goods have been conducted.

The identification process of hot spots has also covered a research of map material from VV and SRV. VV's maps represent the recommended roads for transportation of dangerous goods and give important information about how the roads are reaching through sensitive ecological areas or high-populated areas. The amount of dangerous goods transported by roads, sorted by class, has been estimated by using SRV's maps of transports flows.

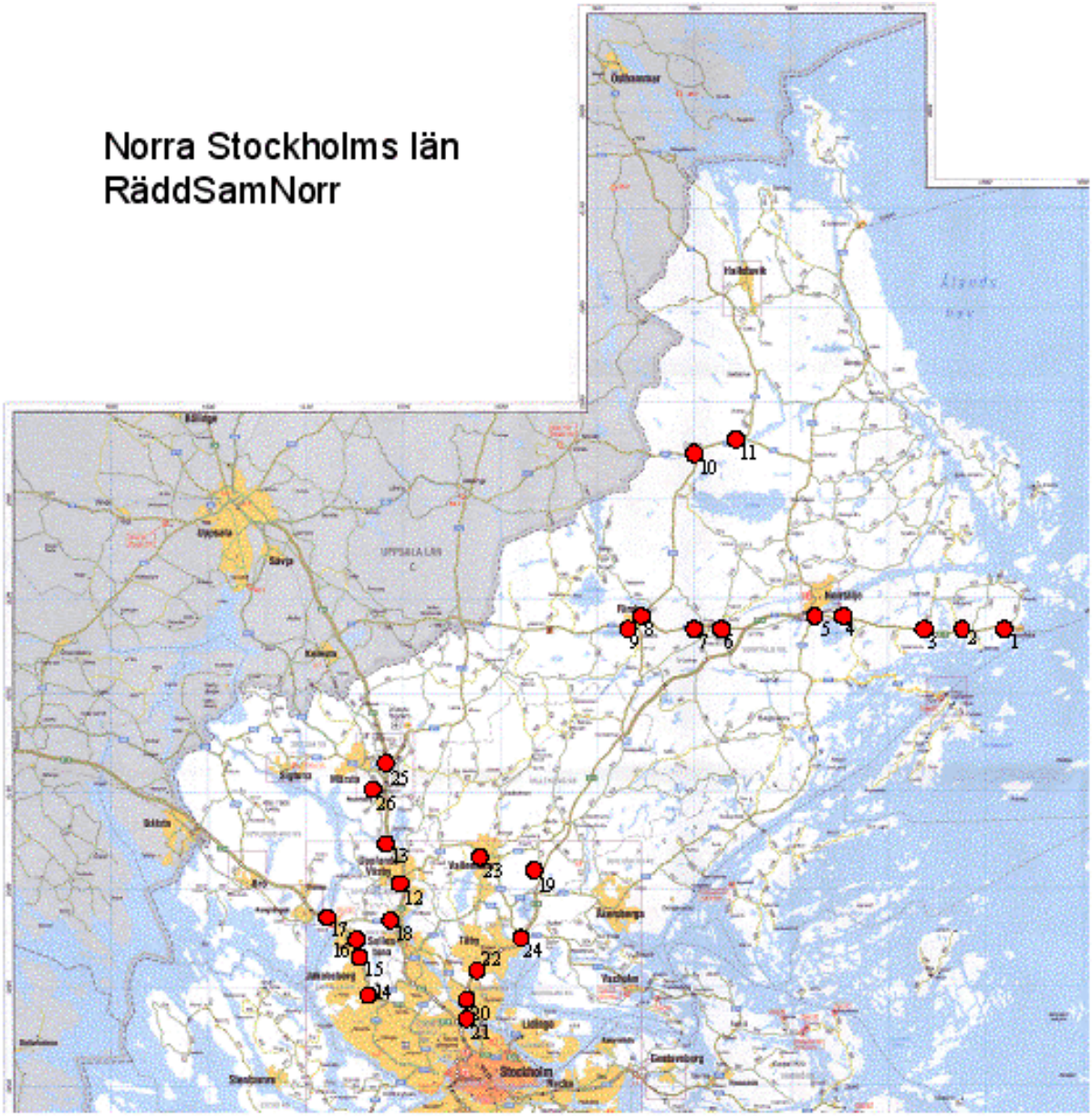


Figure 1, The 26 hot spot sites in the region RSN

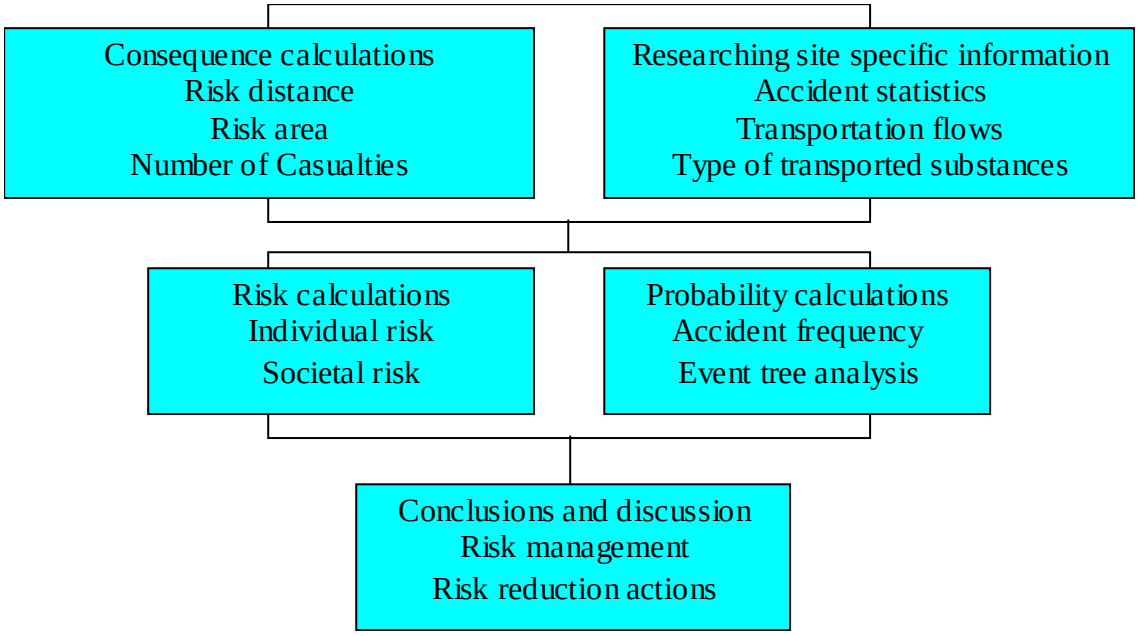
The identification work has been compiled as a hot spot list consisting of 26, see figure 1, different places of interest. By using a rough selection four places have been chosen for a more profound risk analysis. The places are: 1 the harbor of Kapelskär, 9 the high-populated area of Rimbo, 18 the train station in Rotebro and 25, Arlanda city

Work method

Figure 2 represents the work method of this study.

Conclusions

The chosen sites for this study generate high levels of societal and individual risk. It is of great interest to note that the results of this study should not be treated as the absolute truth. The results of this study should be used only for the purpose of comparing the risk situations between different sites. For example: Are the individual and the societal risk levels higher in Arlanda city compared with Rimbo? The high levels of individual and societal risks are motivated by the assumed high frequency of dangerous goods transportations through the chosen sites. There has been no consideration taken for factors that can influence the traffic safety such as: traffic signs, road width, etc. The method gives a clear and easy to understand result which can be used as a tool for comparing different effects of risk reduction actions.



The study has resulted in a general method for the calculation of risks which at the present time is a rough tool. The method is based on assumptions and simplifications which propagate through the calculations and affect the results. A lack in the calculation model is that it doesn't take in consideration the transit transports through the region because of tha lack of information about those transports. Those transports should be registered to appropriate instance so that usable information can be accessed and in this way make the model in this study a better tool for risk calculations.

The biggest difficulty in this study has been gathering useful statistical data, for example the distribution of chemicals within chemical classes or the amount of transported chemicals. This lack of information can be related to different market actors and their fear of be associated with risks.

To create better conditions for better risk analyses and studies on the risks associated with the transports of dangerous goods, should the instances involved in the transportation of dangerous goods be imposed by the law to leave useful information. There are approximately 25 laws that are treating the dangerous goods. Only two of these laws treat the dangerous goods transports specifically. This could be interpreted as if the transports of dangerous goods are not related to accidents in the same perspective as factory premises that are handling dangerous substances. Several statistical reports show that the biggest releases of dangerous substances, in the latest years, came from accidents where dangerous transports were involved. An improvement of the present situation could be achieved through a law change, for example the environment code could be change so that includes the transports of dangerous goods. Unfortunately it is often that it takes an accident to happen to achieve a law change. For example it could be mentioned that the Seveso directive came as result of a chemical catastrophe. The law changing process is also long from a time perspective. A interpretation of an existing law is definitely a faster and more appropriate method for achieving changes. A parallel could be drawn from Malmö fire department's interpretation of RtjL 41§. Malmö fire department has chosen to interpret the law text as every apartment in Malmö must be equipped with smoke detectors. As result of this action 95 percent of Malmö's apartments have smoke detectors. The law interpretation has led to a powerful reducing of the death casualties from apartment fires.

Similar interpretations could be made for the dangerous goods transports. In several law text it is mentioned that the urban and rural districts must take measures to prevent, limit or eliminate damages and risks on the environment end people. To accomplish that it is essential that information about the dangerous goods transports in the society is easily reached. It is of great importance that the law instances impose an information responsibility on those who handle the transportation of dangerous goods.

Risk Assessment at DuPont Chemoswed and an Analysis of How Risk can be Presented and Evaluated

Helena Hermansson
Malin Sörqvist

Due to regulations, Malmo Fire Department demanded a new risk assessment for DuPont Chemosweds plants in Malmo, Sweden. The plants are situated in two blocks, Degeln, where pharmaceutical substances are produced, and Smedjan, where research and development is carried out. In the earlier risk assessment the focus was on the usage of Warfarin, which was the reason for being classified as a "SEVESO I"-plant. As the "SEVESO I"-directive was replaced by the SEVESO II-directive in 1996 the limit for usage of Warfarin was raised from 0,1 to 50 tons. Therefore DuPont Chemoswed was not classified as a SEVESO II-plant, but is still affected by other regulations, as for example räddningstjänstlagen (SFS 1986:1102).

Today there are neither consequence measures, risk measures nor risk targets specified for usage in risk assessments. Therefore every risk assessment is based on different consequences and presented and evaluated with different methods.

The aim of this project was to perform a quantitative risk assessment for DuPont Chemoswed and to analyze different consequence measures, risk measures and risk targets. A recommendation for a suitable risk measure for a plant using chemicals, like DuPont Chemoswed, was also to be presented.

In the required risk assessment Malmo Fire Department asked for the risk to be presented as probability of death for the public. This should be done in individual risk contour plots and F-N curves.

DuPont Chemoswed manufactures several medical substances. Warfarin is the main substance and is an anticoagulant.

In the risk analysis possible scenarios at DuPont Chemoswed were listed. The probabilities and consequences were calculated for those scenarios which DuPont Chemoswed generates, and which consequences might affect the public. The scenarios with the worst expected effects were first calculated. As they did not result in any expected death for the public, similar, but less dangerous, scenarios were disregarded. In total consequences for eight different scenarios were calculated. The consequences which were calculated and evaluated are:

- Radiation from pool fires
- Blast pressure from explosions (dust and hydrogen)
- Exposure from Warfarin in fire induced smoke

For all calculations a sensitivity analysis was performed.
The results from the quantitative risk analysis were that no death among the public ought to occur. As the results did not vary considerable in the sensitivity analysis no uncertainty analysis was performed. Neither individual risk contour plot nor F-N curve presents a full view of the company's risks. Even though there is almost no probability for death, among the public, people still might get injured.

If a pool fire should happen in the tank farm, it is possible that a fire will spread to the nearest building of the company that shares the block Degeln with DuPont Chemoswed. Explosions might cause windows to break on buildings in the surroundings of both Degeln and Smedjan.

Lately more demands to analyze risks has been introduced in regulations. Therefore more risk assessment will probably be executed in the future. As mentioned earlier neither consequence measures, risk measures nor risk targets for usage in risk assessments are specified. As a result of that, every risk assessment is based on different consequences and presented and evaluated with different methods. To make sure that decisions are made objectively, uniformity is preferable. To ensure this, some kind of risk targets could be used. Fixed targets are not to be preferred, as they do not allow decision makers to make decisions based on local conditions. With a fixed limit companies tends to feel, that they do not need to improve safety further more, if

they are below the risk target. Safety management should always be a part in every company's activity.

The amount of information which is searched for in a risk assessment is great. The public is mostly interested in some kind of individual risk, the politicians and decision makers are interested in some kind of societal risk as well. Fire Departments on the other hand are looking for distances to certain risks in case of an accident, as well as individual and societal risk for prevention work. The companies themselves are interested in which risk sources to take measures against first. All this information is not possible to gain from any of the present ways to present and evaluate risk.

Instead a new way to present and evaluate risk was developed. It is a 3-dimensional matrix with the dimensions consequence, frequency and distance, see Figure 1 below. The distance axis is continuous while the other two are discreet with numerical intervals. The matrix is based on a quantitative risk analysis but the results are not presented as exact values. No fixed risk targets are used, instead a sliding scale from yellow to red, where the latter express that the risk is not acceptable. Sensitive buildings like hospitals and schools can also be marked in the matrix.

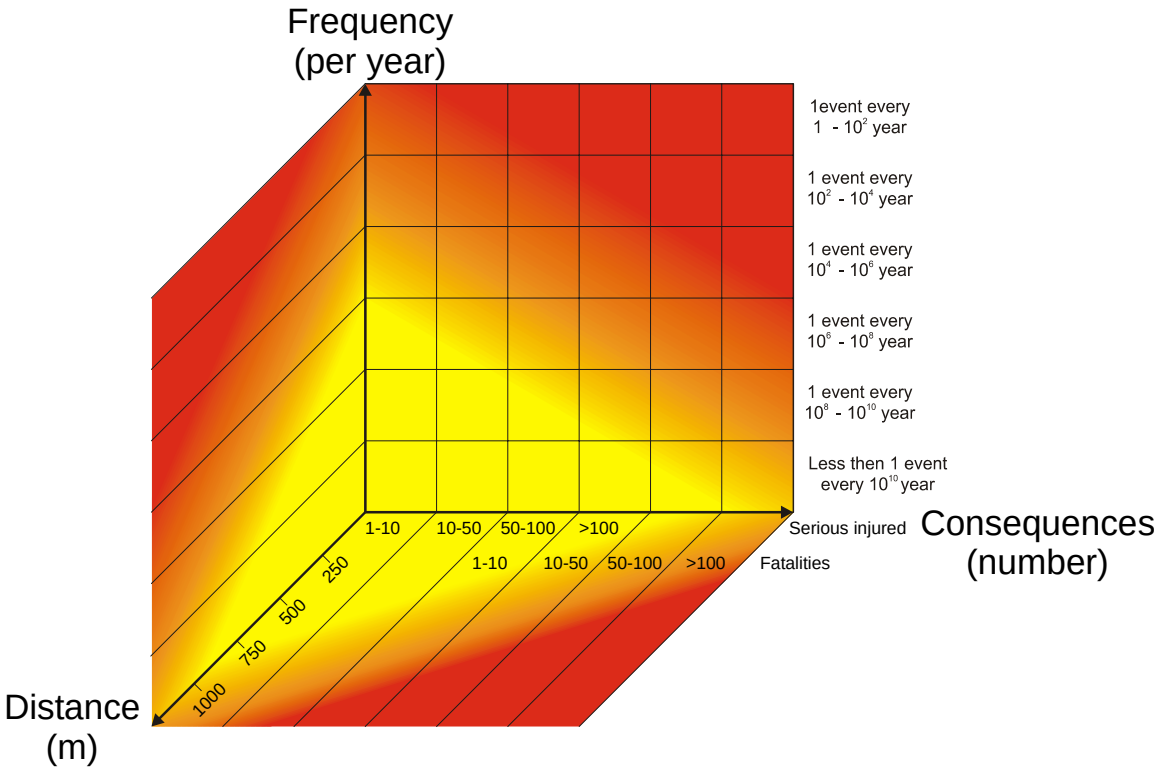


Figure 1, Schematic presentation of the 3-dimensional presentation and evaluation model.

Some advantages with the 3-dimesional matrix is the large amount of information, which is presented in a graphic way. The matrix presents individual risk and societal risk as well as distances to certain risks. The axes intervals directly indicate that no calculation results are precise. All calculations include uncertainty, assumptions and simplifications. The risk target guide decision makers, but allow decisions to be made based on local conditions. It is easy to upgrade the matrix as the conditions change. The dots, that mark different risks, can be removed, added or moved based on the changes that are made.

This 3-dimensional matrix is suitable as a method to present and evaluate risk for DuPont Chemosweds plants because injured are included in the risk assessment, and not only deaths.

The method is, at this stage, just a prototype and needs to be validated, evaluated and modified, before it can be used commercially.

Risk Investigation of Flammable Substances – Template and application

Christoffer Bonthron
Sandra Danielsson

According to the Swedish legislation for flammable and explosive materials a risk investigation should be made, when flammable goods are professionally handled with. The Swedish supervisory authority Sprängämnesinspektionen describes the requirements in their regulation SÄIFS 2000:2. Among those, there is a requirement for a risk investigation.

As a part of the thesis a template was developed. The template is made to help performing risk investigations according to SÄIFS 2000:2, and is first and foremost applicable for research and development (R&D) activities. The template can be used as a support in the work and has been flexibly created, believing that the main features in every risk investigation are the same. Depending on the type of the activity the investigator can change, add or remove parts of the template.

The outline of the template is based on Sprängämnesinspektionen's advice, illustrated by figure 1.

As an application of the template a risk investigation of Kemicentrum is presented in the report. Kemicentrum is a part of Lund Institute of Technology at Lund University and the biggest centre of chemical R&D and education in the Nordic countries. According to SÄIFS 2000:2 the investigation should show that the activity is considered to be safe and, if it is not, what actions are to be taken to make it secure.

An inventory of the flammable materials was made. It turned out that there are large quantities of the flammable liquid acetone, ethanol and methanol, and of the flammable gases acetylene, hydrogen and propane.

Acetone, ethanol and hydrogen were subjects to further investigation. They were chosen to represent the most common materials at Kemicentrum.

The analysis was done through estimating the probabilities and consequences of incidents with the flammable materials. The consequences were appreciated through assumptions, calculations, simulations and valuations. The computer-based programme FAST was used for estimating fire developments and the computer-based programme Simulex was used for estimating evacuations. Different, credible scenarios were simulated with those programmes. The scenarios were chosen to represent the worst, credible cases that could be considered to be able to occur at Kemicentrum in case of an incident with flammable materials.

The analysis was performed as a Level 2 analysis. The level is closer described in the article "Uncertainties in risk analysis: Six levels of treatment" written by Elisabeth Paté-Cornell at Stanford university (1994).

The interaction between the personnel, technology and organization was studied. This was made by studying the logistics of the flammable materials. Sensitive moments were found, where an incident could happen and also why. The study also resulted in a lot of suggestions of improvements. These improvements are often easy to reform for an insignificant amount.

This study included a theory part, where different factors that influence the work environment were investigated. This showed that it is mostly the organization that is insufficient when the "human error" is blamed for an incident. It also showed that education is an important part in the prevention of incidents.

A traditional risk analysis was used to determine the consequences of an incident. It was also a tool to find which improvements that can be done to make Kemicentrum safer.

The investigation showed that, in the present circumstances at Kemicentrum, the activity is not to be considered safe and sufficient. If the suggestions for improvements given in this report are followed, the level of safety is to be considered satisfactory.

The measures suggested broadly mean the following:

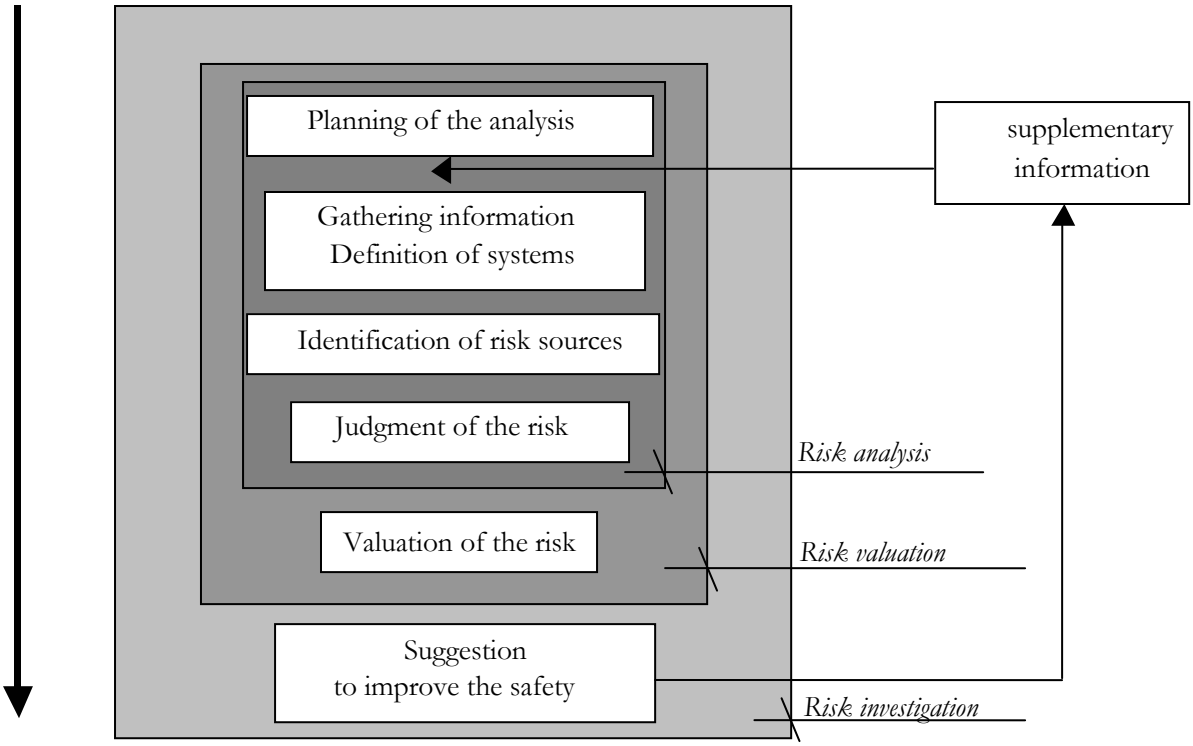


Figure 1 A template to perform risk investigations according to SÄIFS 2000:2

- A functional system for inventory of flammable material shall be developed
- The handling with flammable liquids shall be decreased from 10 liters to 2 liters at the laboratories
- The fire detection system shall be changed to a multidetector system
- The fire detection system shall be expanded to cover all spaces where flammable materials are used
- A special lift for transporting the chemicals shall be installed
- Gas cylinders shall be placed in specially designed spaces in the corridors

A new lift is already planned to be installed as a part of the rebuilding project. Additionally, an expansion of the detection system is mentioned in the fire safety documentation of the building. The amount of flammable liquid handled at the same time should also be possible to decrease. Already today is Kemicentrum working to decrease the amount of flammable material and the bottles used mostly contain 1 liter or 2,5 liters. The work with specially designed spaces for gases is also started.

A couple of less expensive, but nevertheless efficient measures are suggested as well. It mainly involves improvements for the chemical logistics and how the organization can be more safety orientated.

Use of Quantitative Microbial Risk Assessment (QMRA) as a Tool in the Hazard Analysis and Critical Control Point (HACCP) Management System for Water Treatment Plants – Especially for Development of Critical Limits

Rebecka Thorwaldsdotter

Abstract

The primary objective for a drinking water supplier is to provide water that is safe for the public to drink and use. To improve process quality, it has been highlighted that a new approach is needed. A new risk based approach has been introduced by the World Health Organization. The recommended way to undertake risk assessment is by performing a Quantitative Microbial Risk Assessment (QMRA) whereas the risk management is proposed to rely on a management system named Water Safety Plan which includes the management system Hazard Analysis and Critical Control Point (HACCP) originating from the food industry. The overall purpose of this M.Sc. project is to evaluate and determine if and how QMRA can be used as a basis for an HACCP-style analysis in the water treatment industry. Focus is particularly on how to develop critical limits. The course of action was to perform a QMRA at a case plant. The choice of interesting issues to simulate was opted by the author after discussion with associates and in the light of HACCP. A simple model was created and simulations were made in an MS Excel program that was connected to Palisade @risk v.4.5 (@risk). The main conclusion was that a QMRA can be used as input to HACCP for Water Treatment Plants (WTPs). Establishment of critical limits could be based on duration of process failure, on number of hazardous events and on incoming pathogen concentration. The performance of a QMRA will provide a better understanding of the whole WTP. However, at the moment there is a big limitation in existing data and there are also some differences between the food industry and the WTP that must be taken into account.

Introduction

The primary objective for a drinking water supplier is to provide water that is safe for the public to drink and use. Microbiological safety is based upon the multiple barrier concept and the quality is maintained by protection of source water, application of treatment processes within the treatment plant and protection of the distribution system (Hunter *et al.*, 2003). To ensure that a water treatment process works properly, monitoring of different parameters such as pH, temperature, turbidity, alkalinity and indicator-bacteria are performed and compared to established standards (Roser, 2006).

To improve process quality, it has been highlighted that a new approach is needed. First of all, waterborne diseases have occurred even though standards have been fulfilled (WHO, 2005). Another objection for today's management is that the results from sampling often become available too late (after the water already has reached the consumer) (Medema & Smeets, 2004). An additional issue is the cost. In a community there are a lot of risks and costs for safety work. It is important to be efficient in the safety work and to direct resources to where they best will contribute to the overall risk reduction. Therefore an approach that can minimize the overall risk in the system is preferable.

A new risk based approach, the Safe Water Framework, has been introduced by the World Health Organization (WHO). The Safe Water Framework is an iterative methodology where risk assessments along with specified health targets constitute the basis for risk management (Fewtrell & Bartram, 2001).

The recommended way to undertake risk assessment is by performing a health-based Quantitative Microbial Risk Assessment (QMRA) whereas the risk management is proposed to rely on a management system named Water Safety Plan which includes the management system Hazard Analysis and Critical Control Point (HACCP). (WHO, 2004; WHO, 2005)

HACCP is a widely used management system for controlling a variety of safety hazards within the food industry. It is a systematic method based on seven main principles, and it is from its origin a semi-quantitative method, i.e., judgement about the importance of a hazard and its probability to occur can be based on the opinion and experience of experts. (NACMCF, 1997)

"Hazardous event" is an important concept within HACCP. A hazardous event is an incident or situation that can contribute to the presence of a hazard (Nadebaum *et al.*, 2004).

The seven principles of HACCP are: (NACMCF, 1997)

1: Conduct a hazard analysis

2: Determine the critical control points (CCPs)

3: Establish critical limits

4: Establish monitoring procedures

5: Establish corrective actions (if the critical limit is exceeded)

6: Establish verification procedures

7: Establish record-keeping and documentation procedures

Objective

The overall purpose of this M.Sc. project is to evaluate and determine if and how QMRA can be used as a basis for an HACCP-style analysis in the water treatment industry. The aim is to describe how the three first HACCP principles can be performed at a water treatment plant when results from a QMRA are used. Focus is particularly on how to develop critical limits.

Method

The course of action was to perform a QMRA at a case plant. Lackarebäck Water Treatment Plant (LWTP) located in Gothenburg, Sweden, was used for the case study. A general framework for assessing microbial risk for drinking water called "Plan for QMRA for CTSs" (Petterson *et al.*, 2004) was used and a simple model of the treatment plant was created in MS Excel. The input was pathogen concentration in the water upstream the treatment process and the model was calculating the concentration of pathogens downstream. By assessing the average water consumption per customer and combining the results with dose-response relationships, pathogen exposure could be related to health outcomes. Results from simulations were presented as infection risk and annual infection risk. Annual infection risk gives the answer to how many infections per 10 000 persons and year that can be expected from each pathogen. To be able to assess the infection risks obtained from the simulations the Dutch Drinking Water Degree required level of safety was consistently used as a reference. This says that one infection per 10 000 persons and year is the acceptable level (Hijnen *et al.*, 2005).

The choice of interesting issues to simulate and the way of action when critical limits should be established was opted by the author after discussion with associates and in the light of HACCP. The results were then tested for how well they fit into the first three principles of HACCP.

Main issues in the case study were:

- *Infection risk under normal conditions - base line scenario*
- *Critical incoming concentration under base line conditions*
- *Additional infection risk for hazardous events*
- *Infection risk versus duration of failure*
- *Sensitivity analysis*

Simulations were made in an MS Excel program that was connected to Palisade @risk v.4.5 (@risk, 2004). @risk makes it possible to use distribution functions instead of point values and uncertainty can be presented with an arbitrary percentile. Three pathogens were used as index organisms: *Cryptosporidium,* Norovirus and *Campylobacter.*

Results

The main conclusion was that a QMRA can be used as input to HACCP for water treatment plants.

The simulated infection risk from a QMRA could provide the analysis with information about which pathogen that must be prioritized and which pathogen that should be involved in the HACCP performance, which corresponds to HACCP-principle 1.

As a starting point when making a judgement about CCP (HACCP-principle 2) the suggested approach was to use each treatment step within the water treatment plant as an important control point and also to involve the point where the incoming water is entering the plant.

Pathogen concentration was suggested as one basis for the establishment of critical limits (HACCP-principle 3). Other suggestions were to use simulations of hazardous events and process failures. By performing hazardous event simulations the additional infection risk could be calculated for each hazardous event. These results give good information about which hazardous events that have to be prioritized and how many of these events that can be tolerated before the level of acceptable infections is exceeded. Graphs with infection risk plotted against duration of failure can work as a basis for judgment about how long time a failure can be tolerated before the level of acceptable infection is exceeded.

In the analysis of QMRA performance it was stated that the performance of a QMRA will provide a better understanding of the whole WTP. It will lead to identification of actual barriers and a better understanding about lack of knowledge. It will also lead to learning about new scenarios and events. At the moment there is a big limitation in existing data.

Discussion

The main conclusion was that a QMRA can be used as input to HACCP for water treatment plants. However, there are some differences between the food industry and the WTP and they must be taken into account. One example of this is the initial product. Within the food industry microbial contamination is expected to occur somewhere within the walls of the industry. For WTP the pathogens are already present when the raw water enters the plant.

The main issue when performing the simulations was the choice of data. It was very difficult to find and/or to know what kind of data to use. With all of the data, there were associated uncertainties and high variability. However, the results of this study have shown that the output from a QMRA can provide knowledge of the plant that can be used in the management of a WTP. By collecting all of the data in a data system it is easy to improve the model and update simulations gradually when better data are received.

The fact that a specific WTP was used for a case study does not have any effect on the suggestion on how QMRA should be used with the first three principles of HACCP. The performance should be the same for each water treatment plant.

It should be remembered that the suggestions about HACCP performance made in this project are not to be considered as complete. More work has to be done in order to gain experience and widen the knowledge.

Finally it was stated that an additional use of this project is that it can act as a basis for further discussions of HACCP principles within the water treatment plan.

References

Fewtrell, L., Bartram, J., (2001). *Water Quality: Guidelines, Standards and Health, Assessment of risk and risk management for water-related infectious disease.* World Health Organisation (WHO). Geneva, Switzerland.

Hijnen, W.A.M., Beerendonk, E., Medeman, G.J., (2005). *"Elimination of microorganisms by drinking water treatment processes".* Second Edition, August 2005. Kiwa Water Research, Nieuwegein, the Netherlands.

Hunter, P.R., Waite, M., Ronchi, E., (2003). *"Drinking Water and infectious diseases. Establishing the links".* Chapter 9. IWA Publishing.

Medema, G., Smeets, P., (2004). *"The interaction between Quantitative Microbial Risk Assessment and risk management in the Water Safety Plan".* Microrisk project report, February 2004. Kiwa Water Research, Nieuwegein, the Netherlands.

NACMCF (The National Advisory Committee on Microbiological Criteria for Foods) (1997). *"Hazard Analysis and Critical Control Point Principles and Application Guidelines".* U. S. Department of Agriculture (USDA).

Nadebaum, P., Chapman, M., Morden, R., Rizak, S., (2004). *"A Guide to Hazard Identification & Risk Assessment for Drinking Water Supplies".* Cooperative Research Centre for Water Quality and Treatment. April 2004. (Report 11). Salisbury, Australia.

Petterson, S., Smeets, P., Ashbolt, N., Medema, G., (2004). *"Plan for QMRA for CTSs"*. Water Science and Technology. Vol 50, no 2, pp 23-30. IWA Publishing 2004.

Roser, D., (2006). Personal communication. Centre for Water and Waste Technology, University of New South Wales, Sydney, Australia.

WHO (2004). *"Guidelines for Drinking-Water Quality"*. Third edition, Vol 1. Recommendations. WHO, Geneva, Switzerland.

WHO (2005). *Water Safety Plans, Managing drinking-water quality from catchment to consumer*. WHO, Geneva, Switzerland.

@RISK, (2004). *"Risk Analysis and Simulation Add-In for Microsoft Excel"*, Version 4.5, February 2004. Palisade Corporation. USA.

The use of water treatment SCADA data to quantify hazardous microbiological events and risks arising – A case study from Sweden

Per Nilsson

Abstract

As outbreaks of waterborne diseases caused by pathogenic micro-organisms still occur in developing as well as in developed countries, strategies for improving water quality can be expected to deliver substantial health gains. The overall objective of this MSc project was to critically evaluate the use of on-line monitoring data sets in quantitative microbial risk assessment (QMRA) and its implications for risk management for water treatment plants. This has been done by studying Supervisory Control and Data Acquisition (SCADA) data from Lackarebäck Water Treatment Plant (LWTP) in Gothenburg. By analysing SCADA data sets in parallel with diary records and deviation reports, the advantages and limits to the SCADA data in its ability to identify frequencies, duration and magnitude of hazardous events were assessed. The analysis showed that it was possible to identify possibly hazardous events by identifying deviations in turbidity, chlorine residual or pH SCADA data sets. SCADA systems have the potential for on-line identification of short term events that otherwise would have passed undetected. However, SCADA data sets do not provide information regarding all safety issues for the system and it is associated with a lot of uncertainties and should, hence, be seen as a compliment to traditional grab sampling rather than as a replacement.

Introduction

The primary objective of drinking water supply is to provide water that is safe for the public to drink. The microbiological quality of drinking water is maintained by selecting good quality source water, application of treatment processes in water treatment plants and protection of distribution system. To assure that water treatment processes work properly they are monitored in real time by online control and monitoring systems, that is Supervisory Control and Data Acquisition (SCADA) systems. On a regular basis these systems collect parameters such as flow, turbidity, pH, disinfectant residuals and temperature along the production line. Although these measures of process performance cannot be directly translated into pathogen removal, they can still prove to be a valuable source of information for undertaking assessments of risks.

Objective

The overall objective of this MSc project was to critically evaluate the use of SCADA parameter data sets with a view to using them in Quantitative Microbial Risk Assessment (QMRA) and their use for risk management of water treatment plants.

Method

The overall method to reach the objectives was to pursue a literature study followed by a case study. The literature study was undertaken to survey similar previous work and to cover other relevant theory. The case study was undertaken to address the problem on a real case using Lackarebäck Water Treatment Plant as a case study.

Background

As outbreaks of waterborne diseases caused by pathogenic micro-organisms still occur in developing as well as in developed countries, strategies for improving water quality can be expected to deliver substantial health gains (WHO, 2005). A new risk based approach, the Safe Water Framework, has been introduced by the WHO as a new strategy for the provision of water that is safe to drink (Fewtrell & Bartram, 2001). The Safe Water Framework is an iterative

methodology where risk assessment along with specified health targets will constitute the basis for risk management. The proposed way to undertake the risk assessment is by QMRA whereas the risk management is proposed to rely on a management system named the Water Safety Plan including the management tool Hazard Analysis and Critical Control Point (HACCP). The rationale of HACCP is to control hazards at the time of manufacture rather than trying to detect problems by testing the end product. The method is based upon identification of each step within the process that can be crucial regarding to the safety and thereafter the taking of corrective action to reduce the risks.

By tradition, quantification of microbial risks in the water community has been made on the basis of grab sampling and epidemiology. This method has generally resulted in drinking water of high quality but has over the years showed some shortcomings (Medema & Smeets, 2004). To manage these shortcomings QMRA has been proposed as the new way to assess risks in the water community (WHO, 2004). The objective of QMRA is to identify and quantify the risk of infections. To quantify risks – frequencies and magnitudes of hazardous events must be measured. A hazardous event is defined as an incident or situation that can contribute to the presence of a hazard where a hazard is a biological, chemical or physical agent that has the potential to cause harm and/or give rise to water quality which is unacceptable for consumers (Nadebaum *et al.,* 2004).

LeChevallier & Au (2004) and WHO (2004) propose that health effects associated with pathogens tend to be due to short-term rather than long-term exposure. Westrell *et al* (2003) state that it is clear that it is under normal conditions and not during failures, that most infectious matter bypasses the treatment. A starting point for this thesis has been that managing small undetected events can be an efficient way of reducing health risks.

SCADA data systems are commonly used in the water supply industry (Scott *et al.,* 1999). These systems automatically collect and store data at short intervals and are, in theory, suitable as inputs for QMRA. There do not seem to be any standards for undertaking analysis of the sampled data for this purpose. Time series analysis is a methodology to understand time series such as those generated by SCADA systems. Control charting and Cumulative Sum Control Charting (CUSUM) analysis are both well proven industry quality control methods and applicable to SCADA data sets. This thesis explores how those methods can contribute to QMRA.

The case study

Göteborg Water and Wastewater Works supply drinking water in the Gothenburg area. Göta älv is being used as the source water and the drinking water is produced at the two plants Alelyckan and Lackarebäck Water Treatment Plant. The treatment processes include coagulation, sedimentation, granulated active carbon filtration and disinfection. The process is monitored by SCADA systems. Diary records are taken on a daily basis and cover day to day issues such as general observations, maintenance and small incidents. Major events that could have an impact on the overall process performance are recorded in deviation reports.

By analysing diary records and deviation reports parallel with SCADA data sets, advantages and limitations of SCADA in its ability to identify frequencies, durations and magnitudes of events, could be proved. 10-minute mean values for the time period 01/Oct/2004 to 19/Sep/2005 were compiled. The following parameters were considered being of possible relevance for microbial quality:

- Turbidity in raw water
- Turbidity in filtrate water
- Turbidity in drinking water
- Chlorine residual in raw water weir
- Chlorine residual in drinking water
- pH in flocculation chamber one

These parameters were studied and events were identified and compared to adjacent diary records and deviation reports.

Results

The results of the literature study show that continuous monitoring is a proposed method to improve the risk management process (Cutler, 1997; Scott *et a*l, 1999; WHO, 2004). Scott *et al* (1999) reason that as the society in increasing extent tends to put the risks in focus it is likely that regulators and the public opinion will demand better quality measurements to prevent or manage the risks. Further, Scott *et al* (1999) states that:

"The current reliance on sampling and laboratory analysis exposes companies to the risk of undetected incidents; suggesting the need for continuous measurement so as to demonstrate diligence"

SCADA systems are, in theory, ideal sources of data for quantitative risk assessment as they can record and store large amounts of high resolution data from the process. A lot of sensors can be connected to the system and the data can be displayed the way the user requires (Bailey & Wright, 2003).

However, the literature study also suggests that the use of SCADA data for risk management has several drawbacks. The use of SCADA data is associated with a lot of uncertainties, such as noise. The systems are also complicated and require different operating skills and the operator can not see beyond the sensors (Bailey & Wright, 2003). Furthermore, the conceptual relationship between SCADA data and microbial risk is not always certain.

The results from the case study show that it was possible to estimate frequencies, durations and magnitudes for events as well as statistics for baseline conditions. Different SCADA data time series differed greatly in appearance mainly due to seasonal variations and inherent variability. In total 119 events were identified and classified. 71 % were classified as non-hazardous whereas the other 29 % were classified as possibly hazardous. Of those classified as non-hazardous, 85 % were the result of maintenance and 15 % the result of incidents. Of those classified as possibly hazardous, 76 % were of unknown cause and 24 % were caused by maintenance or incidents. Those events classified as possibly hazardous were further quantified. The duration of identified possibly hazardous events, with few exceptions, ranged between 0.5 and 2.3 hours. The identification and quantification of events and the analysis of corresponding diary records and reports were time demanding if not undertaken in a systematic way. CUSUM proved to be able to detect long-term trends such as possible algae bloom or adjustment of dosing levels.

The classification and quantification of the events as above were based upon 119 events. Still, it is to be seen as a preliminary broad outline classification which is not strictly scientifically underpinned. However, due to the high number of events, uncertainties associated with the classification and quantification of the events were likely to only have a minor impact on the results.

Discussion

SCADA systems are in theory a suitable tool to identify events. Overall positive attributes to SCADA are:

- SCADA data is a good source from which to identify potential hazardous events that otherwise might have passed without detection
- SCADA systems have the potential for on-line event identification which enables a quick response from the operator when an event is at hand
- SCADA analysis adds knowledge about the system and "knowing your system" is a prerequisite for undertaking assessments of risks
- SCADA analysis generates numerical data suitable for QMRA

However, there are many problems associated with the use of SCADA systems. Disadvantages about SCADA are:

- SCADA systems are not likely to detect all events and should, hence, be seen as complimentary to grab sampling and laboratory tests
- SCADA data does not say everything about your system and can thus lull the management into a false sense of safety

- SCADA analysis is to a great extent dependent on accurate diary records
- The use of SCADA data is associated with a lot of uncertainties

More research on the use of SCADA data for microbial risk assessment for water treatment plants needs to be carried out before the methodology can be applied generally. This initial analysis showed that one value of SCADA data lies in its ability to identify and provide estimates of duration of potential hazardous events.

Recommendations

Recommendations coming out from this study are as follows. For further research:

- Studies about how different SCADA parameters are relevant to microbial risks should be pursued
- Studies on the extent of deviation that could contribute to microbial risks should be pursued
- Studies about where to locate SCADA data measuring points relevant for microbial risks should be pursued
- Studies about SCADA systems ability for on-line event identification should be pursued on a set of different water treatment plants
- The use of CUSUM or other statistical process control methods should be further studied on a variety of SCADA data sets from water treatment plants
- On-line monitoring should be integrated with HACCP

For management of water treatment plants:

- Diary records with time reference provide useful information for event identification and should be recorded continuously
- To further reduce the size of SCADA data sets, one option might be to process the data and keep high resolution data during periods of deviation and low resolution data during normal (optimal) conditions
- SCADA data collected during cleaning, maintenance or during periods with unrepresentative monitoring should be annotated, preferably by direct crosslink to an electronic diary

References

Bailey, D., and Wright, E. (2003). *Practical SCADA for industry*. IDC Technology. Newnes

Cutler, A. (1997). *Deming's vision applied to probabilistic risk analysis*. Second Edinburgh Conference on Risk: Analysis, Assessment and Management, September 1997, Edinburgh, UK. [Online]. Available: http://www.sigma-engineering.co.uk/praqual.shtml. (Accessed 25/May/2006).

Fewtrell, L., and Bartram, J. (2001). *Water quality: Guidelines, standards and health. Assessment of risk and risk management for water-related infectious disease*. WHO, Geneva, Switzerland

LeChevallier, M. W., and Au, K-K. (2004). *Water treatment and pathogen control – Process efficiency in achieving safe drinking water*. WHO, Geneva, Switzerland

Medema, G. J., Smeets, P. W. M. H. (2004). *The interaction between Quantitative Microbial Risk Assessment and risk management in the Water Safety Plan*. Microrisk project report. Kiwa Water Research, Nieuwegein, the Netherlands

Nadebaum, P., Chapman, M., Morden, R., and Rizak, S. (2004). *A guide to hazard identification & risk assessment for drinking water supplies*. Cooperative Research Centre for Water Quality and Treatment, Salisbury, Australia

Scott, M., Bogue, R., Marshallsay, D., Thomas, CPL., and Whitworth, C. (1999). *On-line instrumentation standards and practices*. UK Water Industry Research Limited, London, the UK

Westrell, T., Bergstedt, O., Stenström, T.A., and Ashbolt, N.J. (2003). *A theoretical approach to assess microbial risks due to failures in*

drinking water systems. International Journal of Environmental Health Research 13, 181-197 (June 2003)

WHO (2004). *Guidelines for Drinking-water Quality, Third edition, Volume 1: Recommendations*. WHO, Geneva, Switzerland

WHO (2005). *Water Safety Plans, Managing drinking-water quality from catchment to consumer*. WHO, Geneva, Switzerland

Implementation problems in safetywork

Lina Holgersson

Abstract

Municipal safety work is an issue frequently discussed. The new legalisation about accident prevention obeys the Swedish municipality to present an action program for accident prevention. In Borlänge municipality there has been no sanctioned proposal for a program. This report presents the problems found and gives proposals for improvements in the future safety work. The guiding words should be unambiguousness, able to control and not too complicated. Feedback and evaluation are other important parts. Safety work has to be built up on knowledge and education.

Introduction

The new legalisation about accident prevention, which took effect on the first of January 2004, has legal demands on action programmes for accident prevention. Before the Swedish Fire Protection Association yearly branch conference, Brand 2005, a group of fire safety Engineers had the commission to revise the action programmes finished at the end of 2004. Many shortages were found, among these the problems of implementing risk and vulnerability analyses in the decision making process. Difficulties in communicating between employees and policians are a usual problem.

This project has been done as an assignment from Dala Mitt. The purpose of this report is to illustrate existing problems of implementing in the safety work. This report has three objectives:

- To draw up guidelines on how to make implementation of risk and vulnerability analyses work better in the future.
- In Dala Mitts *förstudie angående utformningen av det kommunala säkerhetsarbetet inom Räddningstjänsten Dala Mitt* /2/ there is a schematically model for the municipal safety work. A part of this project is to evaluate the suitability of this model.
- During the work with this project, the objective has also been to prepare a basis for the start-up of municipal accident preventive safety work.

Method

The opening of this project was based on theoretical studies about decisionmaking and legalisations. The organisation of municipals and the county administration was mapped. In order to fulfil the purpose of this report interviews have been done. These interviews have studied the knowledge and information about safety issues among employees and politicians in Borlänge municipal. 15 unit directors and politicians have been interviewed at their place of work. At the county administrative board the director of the Plan and Preparedness unit has been interviewed. To politicians in the committees a questionnaire has been sent by e-mail. The purpose was to survey the safety awareness among the people preparing basic data for decision-making.

Discussion and Conclusion

Literature discussing implementation problems mostly concentrate on the process after decisions. Although these ideas pertain to implementing after political decisions, they can be applied even when it comes to implementing before political decisions. Sannerstedt /1/ shows a number of basic conditions that should exist if the results of implementing shall be as intended. The government must be unambiguous so that it can not be misunderstood. The structure shall not be too complicated. It is also important to arouse approval among the implementers and that the work is controllable.

To implement something, there are three necessary conditions. The implementer must:

- understand the decision,
- be able to implement the decision and

• want to implement the decision. If the implementer understands the decision and in addition have enough resources at his/her disposal, the decision will be implemented, presuppose that the implementer wants to.

According to interviews and questionnaires the understanding can be considered quite low. In many areas there is little knowledge and insecurity in what obligations the municipality has. The respondents are insecure about whether the municipality has a goal for the safety work and in this case what it says. There is no clear distribution of responsibility. The basic knowledge is missing and therefore I consider that a starting point should be to increase the understanding of safety work and the legalisation of accident prevention. The information must be brought into line with the consumers needs.

The bottom line is to make the work lead to constant improvements. To illustrate this there are a lot of different models, one of the best known and applicable is Demings Circle, the so called PDCAcycle /3/. The circle is built up on Plan, Do, Check and Act. This is shown in figure 1 below.

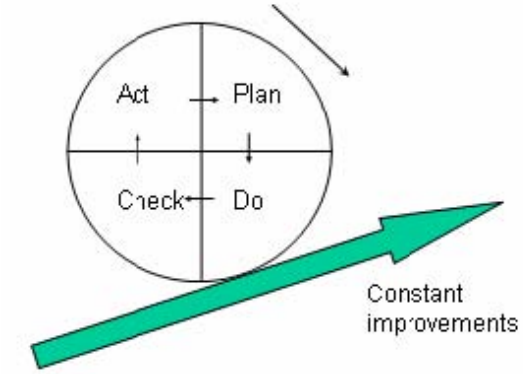


Figure 1. The PDCA-cycle.

Even the model presented by Dala Mitt in *Förstudie angående utformningen av det kommunala säkerhetsarbetet inom Räddningstjänsten Dala Mitt /2/*, resembles to the PDCA-cycle combined with IEC:s classical risk management model. Nevertheless this model is considered to be too complicated for the municipal user. At this time different safety thinking is needed. This process to increase the awareness and knowledge takes time, but is necessary.

If somebody in the future wants to implement risk- and vulnerability analyses, the implementer has to be aware of what gives attention. To get decision makers to take part of the material, it has to be presented to them short and simple. Explanations about the contents of the report and the consequences possible if the report is not taken into account, has to be described easily.

In 1995 Borlänge came to a decision about a policy for the municipal risk management. Although the policy is both legible and contains strategies for how to carry out the safety work, it seems as if politicians and employees don't know that the policy exists. I think that the same incongruity found by the inquiry in 1995, still exists. In ten years no evident improvements have been done. The policy contains most of the guidelines necessary for the municipal safety work and to meet the legal safety requirements. Yet, the lacks of implementing the policy in the different activity units are very obvious and points to an increased need of education.

The following recommendations are given

To the fire department:

- Show yourself in municipal connections e.g. meetings with municipal council. The fire department visiting different activity units is much appreciated.
- Think about being understandable in your information. The message must be easy and important. Be comprehensive that not everybody is experts and sometimes the easy way can be better than the right way.
- Make use of the fact that the municipal has hired a safety coordinator. He is an important resource for both the municipal and for you. Work together with the new steering group so that

they get a clear task, not just becomes one in the number of undefined groups. This group can have an important role in the composition of action programmes.

- Make clear that action programmes for accident prevention is the municipal responsibility
- Be available for help and support.
- Fire is just one problem – focus on safety as a whole.

To the safety coordinator:

- Educate on all levels to get participation and commitment.

- Establish a system for reporting so that the steering group can collect the work done by the activity units.
- Make sure the steering group gets in charge of compiling the action programme from the material collected.
- Goals must be legible and if possible enable follow-up.
- Start with the existing policy. It contains many good general principles and strategies for safety and risk management. If the policy is lived by, safety work is reaching the finishing line instead of still being on the run-up.
- See it as your responsibility to gain approval for the safety questions and the safety thinking among your colleagues at the municipal.
- Call attention to self-interests e.g. insurance premium gets lower, it's good marketing and conducts lower costs for accidents.

- Make better use of the work already done, e.g. fire protection management system, quality assurance and working environment.

The goal is to fulfil the three criteria, understand, be able to and want to. The guiding words should be unambiguousness, able to control and not too complicated. Feedback and evaluation are other important parts.
To be able to identify the risks in each unit, the units needs help and support from the safety coordinator and/or the fire department. An easy method, where all kinds of risks are identified and marked in colours, can be suitable. Risks are assessed with the colours red, yellow and green. Red means the risk is not acceptable and should be dealt with, yellow means the risk has to be checked over and green means the risk is acceptable. An example of this is shown in figure 2 below.

Figure 2. Example of risk assessment

Risks				
accident type	reasons	assessment	measures	responsibility
Falls	Pensioners change curtains, lamps and so forth. Everyday chores		Information about easy measures, "Fixar-Malte", slip protection	unit director
Fire	dry boiling		timers in all apartments	BS

References

/1/. **Sannerstedt**Anders, *Implementering – hur politiska beslut genomförs i praktiken*, i Rothstein Bo, Politik som organisation – Förvaltningspolitikens grundproblem, SNS Förlag, Elanders Graphic Systems AB, Angered, 2001 /2/. **Röjås** Jonas, *Förstudie angående utformningen av det kommunala säkerhetsarbetet inom Räddningstjänsten Dala Mitt*, Borlänge kommun Remissutgåva, 2005-04-11 /3/. **Akselsson** Roland, *Människa, teknik, organisation och riskhantering*, Institutionen för Designvetenskaper, Lunds Tekniska Högskola, Lund, 2004-08-01

Analysis of Fire Protection attributes

Krister Carlens

Abstract

This graduation project examines to study how analysis of different fire protection attributes shall be carried out using technological trade-offs. The purpose of this report is to develop a guidance for engineers to verify technological trade-offs, and therefore make a more reliable verification.

The report shows that safety levels of fire protection as multidimensional. Therefore, several system attributes must be analysed in order to verify that levels of protection comply with Building Regulations at each technical trade-off. For later use in a fictional case, seven system attributes of fire protection are analysed in detail in this report. The result of the report confirms the lack of methods for analysing system attributes of fire protection system. The report shows that theories and line of argument from other disciplines can also be used in fire safety design. In Building Regulations the demands and recommendations are expressed in such a way that it is often difficult to interpret criteria for acceptance of system attributes for fire protection.

Iroduction

For almost 15 years performance-based regulations have been used for the fire protection design in buildings. These performance-based regulations describe *what* the fire protection must fulfil and not *how* the fire protection must be designed to comply with these rules. Through these regulations the fire protection engineer has the possibility to find alternative ways to design the fire protection, so that they will be adapted for the specific building (Frantzich, Lundin & Magnusson 1997).

There are two ways to design the fire protection in a building, through perspective and analytical design. Perspective design follow the demands and general recommendations that can be found in the Building Regulations and in the reports from the Swedish national board of building, housing and planning (Boverket). The design through other methods is called analytical design. When other fire protection measures are applied, besides the ones that have been mandatory placed by Boverket, a so called technological trade-off occurs. Analytical design requires a verification that the level of protection does not reach a lower level of protection received by prescriptive design. Research (Lundin 2001) show that the verification often is faulty. One of the reasons is that too few attributes have been analyzed. The consequences are that the verification becomes insufficient and the risk of apparent safety arises.

Methodology

This report is created to study how the analysis of system attributes of fire protection should be developed for application of the technical trade-off. The purpose of this report is to develop a guidance that the engineer can use at the verification of the technical trade-off, and therefore make a more reliable verification.
To begin with, a study of literature has been carried out to illustrate the problems involving verification of the technical trade-off, and to see how system attributes of fire protection should be analysed. The study of literature has also been extended over several different areas to be able to identify how the system attributes are analysed in other coherences. This study has been created to analyze if the method of analysis can be transferred to fire safety design.

In this report seven attributes that are important to the level of protection of fire protection have been chosen. These attributes have been studied in detail and are applied on a normal technological trade-off, such as traditional sprinkler systems. Traditional sprinkler systems are a measure of protection that serves as a positive effect on several system attributes of the fire protection, and are therefore usually used as technological trade-off.

When these seven attributes have been analysed from a fire protection perspective, the analysis is applied to a fictional case. In this fictional case the traditional sprinkler systems are used as a technical trade-off for fire hose in a grocery store. This alternative design is a recommendation that can be found in the Building Regulations and falls under perspective design. The fictional case is used since the emphasis is on how the analysis of the attributes should happen, and not the actual technical trade-off itself.

Result

The report shows several possibilities and problems that can arise during an analysis of system attributes of the fire protection at a technological trade-off. Here is a conclusion from the results of the report:

- The report shows that a safety level of fire protection is multidimensional, which lead to the fact that important attributes have to be analysed to verify the technical trade-off.
- Traditionally the verification is carried out using methodology of risk-analysis. This methodology cannot handle several of the attributes that influence the level of protection. Therefore, a complementary analysis of the attributes is needed.
- There are few generally accepted methods for analysing the attributes of the fire protection. It could be possible to use other theories and line of arguments from other areas where systems are analysed. However, more research is needed to develop other methods for the analysis of attributes that can be applied to Fire protection context.
- Several attributes for the fire protection have an influence on one another. Therefore, changes within a attributes result in consequences for one or several of the other attributes.
- The intention with some of the demands and recommendations in the Building Regulations are diffuse, which makes the analysis of the attributes more difficult. Therefore, a relative comparison can be applied between the attributes within the new fire protection system and the one received by perceptive dimensioning.

References

Frantzich, H., Lundin, J., Magnusson, S.E., *Slutredovisning från projekten Brandteknisk dimensionering baserad på beräkning (SBUF) och Funktionsbaserad brandteknisk dimensionering (Brandforsk),* Rapport 3093, Lunds Tekniska Högskola, Lund 1997.

Lundin, J., *Verifiering, kontroll och dokumentation vid brandteknisk projektering*, Rapport 3122, Lunds Tekniska Högskola, Lund 2001.

Risk and vulerability Analysis of the Commercial Shipping in the Kattegat

Jens Hagberg

Abstract

This report is a risk and vulnerability analysis of how the commercial ships, i.e. merchant vessels and passenger ships and its goods, can be a threat to the environment and to human health in case of a discharge.

The report presents the most common dangerous goods that are transported at sea through the Kattegat into the Baltic Sea. Accidents occurred have been analyzed in order to find "hot-spots", i.e. places in the Kattegat where accidents are relatively common. This is interesting because the registered ship movements through the Kattegat are expected to increase within a ten-year period.

To a society working more and more with preventive risk management it is not acceptable to have neither control nor the knowledge of exactly what goods are being transported through its waters. Therefore, changes must take place in the shipping trade and, in order to prevent disasters, the sea can no longer be regarded as free.

Introduction

The Kattegat is the main entrance to the Baltic Sea. It is classified as a Particularly Sensitive Sea Area (PSSA) though it is included in the Baltic Sea. An area is classified as a PSSA because of the vulnerability of the nature and thereby very sensitive to risks in connection with the commercial ship transports.

In the year 2000 there were 75,000 registered ship movements in the Kattegat.[1] This figure is expected to increase to 120,000 in the year 2015. Especially oil transports are a large number of the increase. In addition to oil based products there is an infinite number of substances transported. A lot of them can be harmful to both the environment and to human health in case of discharge. The International Maritime Organization (IMO) states that more than half of the substances transported at sea could be regarded as dangerous to the environment due to the large quantities.[2]

This report lists the environmentally sensitive areas along the coast and at sea in the county of Halland. There are a lot of areas that are important to preserve. In the Kattegat there are also important places for fish and birds.

The Kattegat and the Baltic Sea have not yet had any really serious disasters like the Erika or the Prestige accidents.[3] The increase of ships, however, could imply that the risk of an accident involving a discharge could increase.

More important, there are a lot of substances that are transported through the Kattegat that also can be dangerous to human health. One major problem today is the regulations concerning transportation of dangerous goods at sea. These regulations do not lay any merchant vessel, which is only sailing through a country's own waters, under any obligations. This also means that there is a lack of information and knowledge regarding the goods transported.

Method

One of the main objectives with the analysis was to find out what kind of ships and goods pass through the Kattegat and especially if they carry any kind of goods

[1] *Jorma Rytkönen et al: Statistical Analyses of the Baltic Maritime Traffic*
[2] *Kustbevakningens räddningstjänstplan. Miljöräddningstjänst till sjöss*
[3] *Chemical Spills at Sea – Case Studies, Presented by France, Bonn Agreement*

that can be dangerous to the health or the environment.

Further, a hot-spot analysis has been made that investigates the last years' accidents that have taken place in the Kattegat. The positions of the accidents have been marked in a nautical chart. This information has been obtained from Swedish and Danish authorities.[4]

A sensitivity analysis has been made in order to find how the environment at sea and along the coastline in the county of Halland could be affected in case of a discharge. This has been done to show what could be expected if there is an accident with a possible discharge of petroleum products.

Information has been obtained from authorities within the maritime area, The Swedish Maritime Administration and The Swedish Coastguard. The main part of the information has been found on the Internet. Information from the archives of the Country Administration in Halland has also been used.

Result

One of the main problems that this work shows is the lack of information of what has taken place at sea concerning transports of dangerous goods. The sea territory is to be regarded as "free". This means that as long as a ship's purpose only is to pass through a country's territorial water, without making a port of call, it has not got any obligations to inform what kind of goods it has got on board. This means that there are no ways for a country to control and inspect what kind of goods or ships pass through its waters. The only exception is if there are any suspicions of an oil spill. Even then, it is difficult to secure evidence.

This is one reason for the lack of information and there is a great need to update it. Neither the Swedish maritime authorities nor the Danish ones have any useful information on this. The information on types and quantities of dangerous goods, which pass through the Kattegat, and which this study consists of, is two reports from 1988[5] and 1990[6], and they do not give all the answers. However, they give a clear indication what about transportation at sea.

The quantities of petroleum products will increase[7] and this implies more traffic with oil transports through the Kattegat. This could also imply that there are more risks of accidents in the Kattegat because there are no known suggestions to increase the traffic safety in order to prevent accidents.

There have not yet been any serious accidents with major discharges, dangerous to the environment in the Kattegat, but it is necessary to look at the problems now, before something happens. This study shows that there are indications that some areas are more vulnerable. The biggest oil vessel that goes through the Kattegat carries up to 100,000 (metric) tons of oil. In case of a discharge, this would cause enormous problems for the environment in and around the Kattegat.

The environment around the Kattegat is very sensitive if there is a discharge. There are breeding places, which are very important, for several species of fish.[8] Along the coastline there are a lot of areas, which are vulnerable if there is a discharge of petroleum products. Almost all the areas along the coastline are considered an area worth preservation for different reasons. Several areas are also classified as Natura 2000 areas, according to the EU's Birds Directive[9] and Habitats Directive.[10] These are based on the EU's nature preservation policy.

In the southern part of the coastline there are a lot of sandy beaches where it is relatively easy to collect oil spills. The problem in this area is that it has a low level

[4] *The Swedish Maritime Administration and The Danish Maritime Authority*

[5] *HELCOM: Proceedings No. 34*

[6] *HELCOM: Proceedings No. 51*

[7] *Jorma Rytkönen et al: Statistical Analyses of the Baltic Maritime Traffic*

[8] *Länsstyrelsen Halland: Områden av riksintresse för naturvård i Hallands län; 2000-02-07*

[9] *EU's Birds Directive (79/409/EEC)*

[10] *EU's Habitats Directive (92/43/EEC)*

of oxygen. This means that it takes a long time to decompose an oil spill.[11]

The northern part of the coastline has more rocky formations.[13] There are also bays and areas where a major oil spill could be very difficult to decontaminate. Decontamination could also be more harmful to nature compared to leaving the oil to decompose. The latter could take a very long time and the effects on the environment and animals could be very grave.

This study also covers the substances that are not only harmful to nature, but also to human health. One of the substances transported at sea is ammonia, a very toxic gas that is extremely dangerous to human health. The average transport of ammonia is 5,000 (metric) tons. During optimal weather conditions the gas can travel a long distance with a high level of concentration.[12] In a narrow channel, e.g. the sound of Öresund, where there are cities with a high population that could be affected, this could be very serious.

For the county of Halland this would normally not be a major threat, but as the cargo vessels can navigate very close to the baseline, this could be a problem in case of a discharge. It is certainly a problem if a ship, transporting ammonia, starts drifting towards the coast. There are no ways for the authorities to know, what kind of cargo is being transported, if it is not bound for a Swedish port. There are no ways for the authorities to control a ship with dangerous goods.

Discussion

The report indicates that there are a lot of problems that need to be solved in order to control the sea transports. It is important to have a more direct control of the ship movements in the Kattegat and especially the positions. The sea cannot be regarded as "free" anymore. Ships need to have more obligations than today in order to increase security and avoid the serious accidents with discharges of goods, dangerous both to human health and to the environment.

One way to obtain more control is a type of mandatory report system when a ship is entering the Kattegat on its way to the Baltic Sea. The ship should be obliged to give information of what kind of cargo it has got onboard, which destination and which route it is intended to follow. The Danish authorities have a system like this today. Unfortunately, it cannot be mandatory today, due to the regulations of IMO.

The Danish system can be a help to ensure that dangerous goods transports get assistance, e.g. extended area to navigate. The authorities can pay special attention to these cargo vessels to avoid dangerous situations. A mandatory report system also gives statistical information on what types and quantities of dangerous goods are actually transported to the Baltic Sea.

An implementation of a mandatory system like this could be a problem from the commerce and business point of view. However, the Baltic Sea is now classified as a Particularly Sensitive Sea Area (PSSA), which should justify a mandatory report system for the future. This is a something for the Swedish and Danish authorities to analyze.

It should also be possible for the authorities to make flying inspections on the cargo vessels in order to ensure that the condition of the ships is safe and secure. This is probably a little controversial since it could be misused in some cases.

It is also important to make extended analysis of the routes in the Kattegat and work more preventive to ensure that a serious accident could not take place. Today, society is working more and more with risk- and vulnerability analysis and this should also concern sea transports. Changes are necessary even for the whole shipping trade, before a serious accident occurs in the Kattegat.

[11, 13] *IVL rapport: Miljöeffekter – utveckling av kriterier och metoder för bedömning av oljesanering på svenska stränder*

[12] *Försvarets forskningsanstalt: Vådautsläpp av brandfarliga och giftiga gaser och vätskor – Metoder för bedömning av risker*

References

Kustbevakningens räddningstjänstplan (Swedish Coast Guard). Miljöräddningstjänst till sjöss, http://www.kustbevakningen.se/ra/ratjanst/raplan/start.htm, Kustbevakningen 2000

Statistical Analyses of the Baltic Maritime Traffic ; Jorma Rytkönen et al ; 2002; Research Report No VAL34-012344 30.09.02

Study of the Risk for Accidents and the Related Environmental Hazards from the Transportation of Chemicals by Tankers in the Baltic Sea Area Baltic Sea Environmental Proceedings No. 34 ; Baltic Marine Environment Protection Commission - Helsinki Commission 1990; 1SSN 0357-2994

Study of the Transportation of Packaged Dangerous Goods by Sea in the Baltic Sea Area and Related Environmental Hazards, Bait. Sea Environ. Proc. No. 51; HELCOM, 1993; ISSN 0357-2994

Miljöeffekter – utveckling av kriterier och metoder för bedömning av oljesanering på svenska stränder; IVL rapport, Svenska Miljöinstitutet AB; 2004-04-07, Räddningsverket

Länsstyrelsen Halland: Områden av riksintresse för naturvård i Hallands län ; 2000-02-07

Vådautsläpp av brandfarliga och giftiga gaser och vätskor – Metoder för bedömning av risker, Försvarets forskningsanstalt, 3:e reviderade upplagan november 1998, ISSN 1104-9154

Vulnerability analysis - complex system Electrical distribution network

Oskar Johansson
Håkan Nilsson

Abstract

Finance and efficiency have been the focal points of contemporary society for the last few decades. Achieving high efficiency and profitability renders society highly dependent on complex technical systems. The infrastructures are consequently no longer individual systems independent of one another. These independent networks have instead grown to become highly connected networks with a high degree of interdependency. Contemporary society has as a result become more vulnerable.

Introduction

The power grid has expanded at an enormous pace the last century. In the beginning of the century the power grid contained several separate local grids, nowadays it is a complex network interconnected internationally and nationally. Because more and more techniques are dependent of electricity, the electrical power in today's society has become an indispensable asset. The Swedish power grid is a robust and well connected network. This has been well established in a previous vulnerability analysis [1].
Definition: Vulnerability is the effect a specific lost substation/power cable creates on the distribution grid as a whole. This report has included for the analysis essential parameters as, documented risk, length of cable, clustering coefficient and betweenness. Robustness is the opposite of vulnerability.

Methods

In the simulations and calculations of Malmö's distribution grid, two computer programs developed at Lund Institute of Technology by Jonas Johansson, PhD student at Industrial Electrical Engineering and Automation and Henrik Johansson, PhD at the Department of Fire Safety Engineering have been applied.

During the simulations four types of simulation alternatives were available; rejection of vertices with the highest grade, random rejection of a vertex, rejection with highest betweenness and random rejection of edges. When an edge gets rejected one or several vertices could lose contact with the main source vertices and thereby become useless. Simulations will effectively continue until all vertices have lost contact with the main source vertices, which renders them useless. Consequently, one thousand simulations will give a good average value of how fast it takes for a vertex to lose contact with the main source vertices. Every vertex will thereby get an assigned value of how vulnerable it is in relation to the rest of the network. A low value means that it lost connection at an early stage, which is equivalent to a less advantageous placement in the network.

Demarcations

In the report we are analysing the vulnerability of Malmö's distribution grid. The geographic demarcations have been limited to the two primary input stations from the national power grid, Sege and Arrie, which feed electricity to Malmö. Since investigating further down the network will not contribute additional input this analysis has been restricted to the investigation of Malmö's 26 substations in the network.

In this report a graph, specifically an electrical distribution grid, will be considered equal to a technical network. Substations and branches will be represented as vertices. The graph's edges will correspond to cables and transmission lines. The power grid will only be looked upon in a topological aspect. Consequently, no considerations will be taken to any electrical flux, parameters such as transmission capacity and instability will in

other words be excluded. Looking at the power grid from a topological perspective gives a possibility to view the grid from a completely new and unorthodox perspective. The simulations will, however, include both the parameters of fault and break down frequencies

The vulnerability analysis

In vulnerability analysis one considers a hazard from the system's point of view, contrary to a risk analysis where one looks at what harm a specific hazard can do to the system. In a larger context one can say that a vulnerability analysis is a vital part of the bigger concept of crisis management. In other words, a well-executed vulnerability analysis is a prerequisite for good crisis management.
When one does a vulnerability analysis of the critical infrastructure it is of the utmost importance to include the perspective of society. The strain on civilians in larger catastrophes becomes obvious at a very early stage. Since the electrical infrastructure is one of the most essential infrastructures in modern society the consequences of a major break down would be catastrophic. The expansion and interconnection between different power grids have made it more or less impossible to understand and/or predict the stability in the contemporary power grid.

Today's electrical power grid has safety mechanisms for instance should a minor interference in the system for instance occur it would not cause any greater inconvenient consequences. In fact, most errors pass by the common consumer without him ever being aware of it since faulty connections can be isolated, because of high redundancy and automatic switchovers. It is more likely that the common consumer will be affected if errors occur in the lower grid of the grid hierarchy.

When comparing the clustering coefficient C and the average length l of the distribution grid with the former analyses on the Nordic [1] and the West American [2] power grids. An unexpected result was that the West American power grids and Malmö's distribution grid had the same clustering coefficient, table 1.

Table 1. Comparison of clustering coefficient C and average path length l.

Network	***C***	***l***
Malmö's distribution grid	0,080	5,11
Nordic power grid	0,0166	21,75
West USA's power grid	0,080	18,7

This result implies that the West American power grid is as well connected as Malmö's distribution grid. One possible explanation that Malmö's clustering coefficient C is not essentially higher than the American could be that there has been more thought behind the initial design of the West American main power grid. Another explanation could be that Malmö's power grid provides for and follows the city of Malmö's constant dynamic growth and development. The construction of a main power grid is based on a more fixed reality. In other words, cities have fixed geographic positions.

Another interesting observation was when simulations with regards to rejection of vertices with highest grade were executed. A rejection of the vertices with the highest grade did not necessarily result in the most negative effect on the system. Our interpretation and conclusion of this result is that high grade does not necessarily imply high significance for the network as a whole. When designing and constructing a power grid, the main goal should be to design it in such away that every individual station in the network has equal importance and thereby has little or no influence on the grid when rejected. In light of these findings it should be noted that a terrorist attack or sabotage on a high grade station could with little effort cause a large disturbance. During the vulnerability analysis of Malmö's distribution grid, we discovered that when approximately 10% of the vertices were rejected, over 50% of the network lost connection with the main source vertices

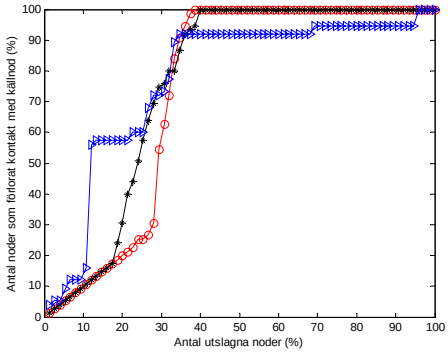


Figure 1. Blue triangles indicate rejection of vertices with highest grade, black stars represent random rejection of vertices with respect to fault and break down frequencies and red circles corresponds to random rejection of vertices without respect to fault and break down frequencies

When observing the analysis results regarding random rejection of vertices, one can initially note a linear behaviour. A collapse of the network does not occur until approximately 30% of the vertices have been rejected, based on simulations where the vertices with higher grade get rejected. The conclusion of the vulnerability analysis on Malmö's distribution grid, regarding rejection of vertices, indicates a robust network.

Simulations have also been done with and without respect to fault and break down frequencies. Despite the fact that it only changed the character of the graph slightly when studying it in a macro perspective, we found that analysing the network in a micro perspective showed significant differences.

Malmö's distribution grid clearly has a few highly vital stations that are essential for the function of the whole network. Consequently, one can conclude that distributing the connections more evenly over all stations or increasing the number of stations would achieve a more robust network. An alternative to this would be islanding, in other words constructing locally generated feedings to the network.

Conclusion

With regards to the applied method of analysis, we conclude that doing a vulnerability analysis on a network like Malmö's, with the help of a topologic study, is both feasible and gives a realistic result. When we first set out to do this analysis those informed in this matter, employed with E.ON, stated that it was a robust network. Our conclusion, having investigated Malmö's distribution grid from a macro perspective, confirms those findings.

With the application of our results (figure 2) on an existing risk analysis we were able to make a list of suggestions prioritising the stations that should be the objects of initial reinvestment and upgrading.

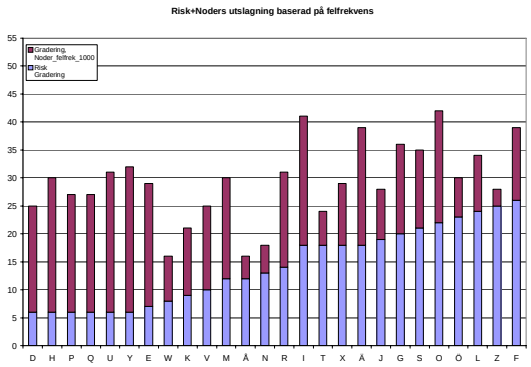


Figure 2. The lower blue bars represent the risk grading and the upper maroon bars represent results of the vulnerability analysis.

References

[1] Holmgren, Å.(2004). Vulnerability Analysis of Electric Power Delivery Networks. KTH Land and Water Resources Engineering. Licentiate Thesis, Stockholm, Sverige, 2004

[2] Watts, D .J. & Strogatz, S. H. (1998). Collective Dynamics of Ssmall-world' Networks. Department of Theoretical and Applied Mechanics, Kimball Hall, Cornell University, Ithaca, New York 14853, USA. Nature, 393.pp.440-442.
http://nicomedia.math.upatras.gr/courses/mnets/mat/Watts&Strogatz_collective_dynamics.pdf
(November 2005)

Urban Search and Rescue -An evaluation of technical search equipment and methods

Carl- Johan Bäckström
Niclas Christoffersson

Abstract

This report evaluates USAR (Urban Search and Rescue) search methods and technical equipment that are in use today by international USAR teams. In addition, improvements to both the search equipment and methods and to USAR in general are considered.

Introduction

Today there exist several different types of USAR search methods and equipment, most of them used in some way by international USAR organisations. The methods and the equipment are in some cases unique for search after live victims in collapsed structures and rubbles.

Up to now, the SRSA (Swedish Rescue Services Agency) has never investigated whether if, or which of the existing and used USAR search equipment or methods that really work under real conditions. Despite this, great efforts are invested to improve methods and equipment without any real knowledge about their efficiency.

The purpose of this report is, in collaboration with the SRSA, to evaluate USAR search methods and equipment that are in use today on international USAR teams. This study also aims to investigate whether or not these methods and equipment work in a real situation.

The following tasks were undertaken to achieve the objectives:

- Identify methods used to detect and locate victims in rubble.
- Identify equipment used to detect and locate victims in rubble.
- Identify the methods and equipment that is most commonly used.
- Review the related advantages and disadvantages to the type of methods and equipment.
- Identify whether or not there are currently any alternative methods or equipment used in other fields of activities that can be useful for USAR.
- Give suggestions for improvement of existing USAR methods and equipment so that the search for live victims becomes more effective.
- Identify the distribution over time of rescued victims related to the different methods and equipment used by the investigated teams

Research

The information essential for this report was in general gathered trough observations, a questionnaire and interviews with people who have participated in earlier USAR operations.

A total of 28 of 56 contacted organisations answered positively to the query to assist in this research. Questionnaires were sent out to those 28. Thirteen completed questionnaires were returned and those from 13 different organisations. In a comparison of the number of organisations that the questionnaire was sent to, this gave the investigation an answer frequency of 13/28 (46.4 %)

Investigated USAR technical search equipment and methods

Technical search equipment,

- Sound or seismic detector (SSD)
- Electric visual detecting device (Search camera)
- Fibre optic detector
- Thermal imaging detector (Infrared camera)
- Canine

Search methods,

- Manual search
- Different methods used with above listed equipment

Combination of different USAR methods and equipment

There are several combinations of methods and equipment used by international USAR teams. Because a search site is dynamic, conditions and information continuously change. The most effective way to use different methods and equipment is therefore to adapt them to existing conditions and the information received on a site.

The combination of different methods and technical equipment used by the investigated organisations during a search of a site follows a general schematic model of an event (Figure. 1).

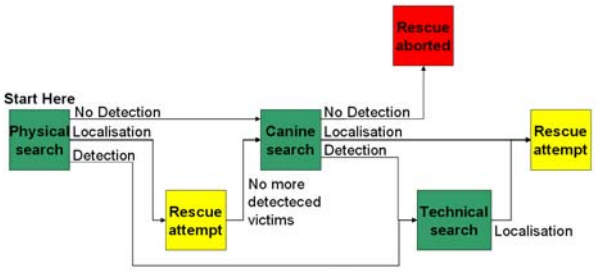


Figure 1 Model of most common USAR method combination. The model is followed from left to right as long as there are indications that there could be a victim trapped in the rubble.

Reporting model

The research shows inferior documentation and spreading of information between the organisations as regards the specific rescue scenarios that have occurred.

To be able to conduct a correct analysis in the future and to improve the different methods and equipment, a suggestion of how a standardised reporting model and the components it should contain are specified.

Information essential for the model is, the day when the rescue took place, type of structural of the rubble, method and equipment used for detection and localisation of victims, number of rescued and the number of deceased on the site or in the object.

Conclusions

- The most common search method and equipment that the investigated teams use is a combination of physically search, canine search and technical localisation equipment.

- Today it does not exist any type of common reporting system for lessons learned during USAR operations, neither any spreading of information on USAR research and development. A better reporting and documentation system would increase the ability for the organisations to share their experience. To avoid that vital information fails to be secured in the future, a common reporting model for international teams should be implemented as soon as possible.
- The effect of the previous international organisations' USAR work cannot be determined without time-consuming procedures.

- Progress and developments that different teams make, often stays inside the different organisations. If double loop learning were used among international organisations, that problem would decrease.

- The scientific analysis of the USAR search methods and equipment used today is too defective to be able to determine the equipments efficiency. Therefore, more research is needed to ascertain the efficiency of today's technical search equipment and search methods.

- More locations of live victims have been made in darkness then in daylight, according to the quantitative analysis of the answers to the questionnaire. To ascertain if the conditions of detecting and locating live victims are better in darkness or "night-time search" a more extensive evaluation is needed.

How are risk information brochures perceived? – theoretical analysis and experimental study of risk information

Elinor Andersson
Jonas Lindsten

Abstract

Swedish law does not give any guidance on presentation of information that should be supplied to people living in the area nearby to potentially dangerous installations. The main purpose of the study is to give recommendations on how to improve the information brochures. Within the study, eight people working with risk information have been interviewed and seven different risk information brochures have been studied. Also, a theoretical analysis and a practical experiment were performed using brochures from two municipalities. Conclusions from the report are that different risk information brochures are perceived in different ways, but the differences are not that big.

Introduction

There are factories and other industrial installations in our society that may be hazardous for its surroundings. The Seveso directive is a part of the European Union's effort to prevent severe chemical accidents caused by these potentially dangerous installations. In Sweden, the directive is mainly governed by the law *Lagen om åtgärder för att förebygga och begränsa följderna av allvarliga kemikalieolyckor* (SFS 1999:381). One of the measures proclaimed by this law is that information about the risks involved shall be distributed to the people living in the area nearby to the installation. In most cases, this information is distributed as brochures.

While the previously discussed law stipulates strict requirements on what information should be supplied to the general public, the law itself does not give any guidance on how such information should be presented. Previous research, both in Sweden and elsewhere, has shown that risk-related information material in many cases does not achieve intended benefits.
The report studies how risk-related information is presented today, and how such information is perceived by different individuals. The study concludes in a number of recommendations on how to improve the information brochures to better serve their purpose. The report is intended for those working with the development of risk information brochures, for example central governments like SRV or industrial installations that are hazardous for its surroundings.

Theory

Today there is no definition of the word risk that is totally accepted or right (Renn, 1998). However, most people do have an intuitive feeling of the meaning of risk, but they can have problem in describing the severity of a situation (Breck, 2002). Risks are perceived in different way by different persons (Jardine & Hrudey, 1997). Factors that affect peoples risk perception are by example if the risk in known or if the person do have any control or use of the risk (Breck, 2002). There is also a difference in the risk perception between genders. Women percept personal risks as more severe (Wester-Herber, 2003).

Choice of words and building of sentences affect how the receiver does percept the risk information (Jardine & Hrudey, 1997). The design also affects how well the receiver can understand the information in a text. People can generally read text faster with good design. It is recommended to use text effects like bold or italic style to draw attention to important parts in a text (Sanders & McCormic, 1992).

Method

The work has involved interviewing eight people working with risk information. A theoretical analysis and an experiment have also been carried through on the two risk information brochures *Om larmet går* (Luleå kommun, 2002) and *Vad du bör göra vid en kemikalieolycka* (Norrköpings kommun, 2003).

The theoretical analysis on the two brochures included sex different factors that were considered to be important. The factors included the definition of risk, choice of color, text effects and the use of pictures and symbols among other things.

The participants in the experiment were students from two colleagues in the west part of Sweden.

Data were collected from four individual groups. In each group, half of the participants read the brochure *Om larmet går* and the other half *Vad du bör göra vid en kemikalieolycka*. The experiment included a 21-unit questionnaire with questions like "The information has given me more information on how I should respond to an alarm" and "I consider to move due to the information I have been given". The respondents gave their answers on a seven step scale, from a negative to a positive alternative.

Several statistical tests were used to reveal significant differences, for example between how the two risk information brochures were perceived or between men and women.

Result

The experiment showed that people who read *Vad du bör göra vid en kemikalieolycka* were more negative to the installation and wanted to move due to the information they had been given. This brochure contained words that can make a reader alarmed, like life-threatening, extremely flammable and convulsion. The use of frightening information is not entirely negative. Information that creates strong emotions is often more easy to remember (Araï, 1999).

Vad du bör göra vid en kemikalieolycka includes more pages and contain more information than *Om larmet går*. A lot of information does not automatically give the reader more knowledge (Bonde-Teir & Westerståhl, 2005). Also, there was no significant difference in how much knowledge the participants said to have gained after reading the two brochures.

The contact information in *Vad du bör göra vid en kemikalieolycka* is written with large text and is easily seen. The contact information in *Om larmet går* is more discreet. People knew were to turn for more information to a higher extent after reading through *Vad du bör göra vid en kemikalieolycka*, according to the experiment.

Typography can affect the readability of a text, even if the literature points out that most types is fit to use in information (Sanders & McCormic, 1992). Choice of type does differ between the two brochures, but the theoretical analysis and the experiment cannot answer which one is the better. *Om larmet går* uses a red color which can be associated with danger (Frantzich, 2004). *Vad du bör göra vid en kemikalieolycka* uses a yellow color which can communicate a lower level of risk compared to red (Edworthy & Adams, 1996). During the interviews, some participants commented on the use of the colors red and yellow, meaning that these colors had been chosen to indicate danger. The experiment shows that red can attain more attention compared to yellow.

There were differences in risk perception between genders in the experiment. Women were more negative and personally affected by the information. Also, women responded to a higher extent that information gave them new thoughts. Previous studies have shown that there are differences in risk perception between genders (Wester-Herber, 2003).

The work resulted in a suggestion of how the risk information brochures can be designed to efficiently communicate with the reader. The most important items are:

- Give direct messages of what the recipient should do: read the brochure, always respond to an alarm and act in the case of an alarm.
- Use pictures and symbols together with text to spread information.
- Use text enhancement and headings to indicate the important parts in the text.
- Use colors that wake attention, red by example.

References

Araï Dariush (1999) *Introduktion till kognitiv psykologi*. Lund: Studentlitteratur.

Bonde-Tier M. & Westerståhl P. (2005) *Direktreklam – från idé till påverkan*. Malmö: Liber Bokförlag.

Breck T. (2002) *Riskkommunikation – Dialog om det osäkra*. Stockholm: Bokförlaget Natur och Kultur.

Jardine C.G. & Hrudey S.E. (1997) Mixed messages in risk communication. *Risk Analysis*, *17 (4)*, 489-498.

Luleå kommun (2002) *Om larmet går*. Formidabel, Luleå grafiska, Luleå.

Norrköpings kommun (2003) *Vad du bör göra vid en kemikalieolycka*. Informationskontoret, Norrköping.

Renn O. (1998) Three decades of risk research. *Journal of Risk Research*, *1 (1)*, 49-71.

Sanders M. S. & McCormick E. J. (1992) *Human factors in engineering and design*. Singapore: McGraw-Hill, Inc.

SFS 1999:381, *Lag om åtgärder för att förebygga och begränsa följderna av allvarliga kemikalieolyckor*.

Wester-Herber M. (2004) *Talking to me? – Risk Communication to a Diverse Public*. Örebro: Örebro Studies in Psychology.

A risk management framework designed for Trelleborg AB

Helena Gustavsson

Abstract

The aim of the thesis is to present a framework for risk management at Trelleborg AB. In doing that a literature study concerning what constitutes good risk management has been performed. Several useful guidelines for how good risk management should be conducted were identified. Risk management documents at Trelleborg were evaluated using these guidelines. Furthermore, complementary interviews with employees were also conducted. It was concluded that Trelleborg AB has a well communicated policy regarding risk management, but lacks routines for many of the risk management activities. Considering these deficiencies a framework for risk management was suggested and implemented in a computer program at Trelleborg AB.

Introduction

Trelleborg AB has been used as an example of the difficulties within risk management that can be encountered in a large company. It has been determine that if there is a need for improvements within risk management at Trelleborg and what kind of improvements. A framework that can facilitate the necessary features has been designed. The framework Improvements a computer based method for risk analysis that can generate basic data for decision-making. It has also been determined which risk analysis method is most appropriate to use to generate basic data for decision-making.

Method and result

The questions that have been answered are the following: What is good risk management and how do you determine the quality of risk management in a company? This question was answered by literature studies. The IEC' features for risk management were chosen as part of good risk management. Another feature that was chosen as good risk management was Cost benefit analysis (CBA) the reason for choosing it is that it will make it easier for Trelleborg to compare different investments benefits. It is important to make some kind of decision after a risk analysis is done. It has also been identified that good risk management includes organisational aspect as safety culture and commitment to safety and to improving the safety culture. It has also been identified that to have good risk management the organisation also needs risk analysis methods that are applicable to their risks and organisation.

The answer to the first question can then be used to provide a point of departure for answering the second question of the thesis: In what areas within risk management does Trelleborg need improvements? To answer this question information on the risk management organisation at Trelleborg was gathered by downloading information that was available on Trelleborg intranet. These documents were analysed by using the results from the first literature study and analysis that was mentioned above. During the analyses areas within risk management that didn't seem to have sufficient routines were identified. These areas were analysed more thoroughly by interviews with employees. To get more structure in the interviews one hypothesis was made: "Trelleborg AB´s risk management policy is not thoroughly communicated within the company". To be able to falsify or verify the hypothesis several interviews with the managers responsible for a specific production and safety mangers were conducted. The answer to this question is that Trelleborg has a well written risk management policy and risk management guidelines. It has also been discovered through interviews that the policy is well communicated within the company and the personnel are well aware of the purpose of Risk Management at Trelleborg AB. This is shown by that the employees are committed to the policy and knows that risk management is important for the company. Through the interviews it was established that there are no established routines for analysis, feedback and follow ups. This is shown by that the employees knows that they should analyse the risks that they are in charge of but they lack directions and have different ways to analyse risks in all parts of the company. Trelleborg weakness lies in that there isn't any system for controlling and following up on the analysis that has been done and there isn't any global system for incident

reporting. It is crucial for top management in a large organisation to have insight of risk management on a local level. If there is a lack of insight it can results in that Trelleborg will be vulnerable if they lose the personnel.

The framework for risk management that has been designed includes some methods for risk analysis. Therefore, the following set of questions needs to be answered: Which criteria should the risk analysis methods that are included in the framework comply with? Which information is needed to establish the criteria? Which risk analysis methods comply with the criteria in the best way? To answer the questions a thorough literature search of the available studies made in this area was performed by using the databases Elin@Lund and Lovisa (at the Lund University Libraries). Through the literature search the criteria for the risk analysis methods were identified and then they were ranked by the personnel the top five criteria, according to the personnel were overview analysis, possible to rank the risk in between, thorough analysis, possible to analyse course of events and simplicity to generate statistics. This shows that the model had to consist of more than one analysis method since the employees found it important to have the possibility to both have a thorough analysis and an overview analysis. The employees also found it important simplicity to generate statistics. The analysis methods that were chosen are checklists, preliminary risk analysis and QRA which will constitute a good mix of risk analysis that fills different needs. Checklists will make it possible to do non time consuming analysis and control predefined risks. Preliminary risk analysis will make it possible to do overview risk analysis that could be used to identify areas that need more thorough analysis. QRA will make it possible to quantify the size on specific risks.

Conclusions

It has been identified that good risk management includes organisational aspect as safety culture and commitment to safety and to improving the safety culture. It has also been identified that to have good risk management the organisation also needs risk analysis methods that are applicable to their risks and organisation.

There are satisfactory opportunities for improvement at Trelleborg AB even with small means. By using the existing system, with some expansion, Trelleborg could easily get a system that spreads information, compares analysis, creates statistics, render possibility to follow up on already made analysis, give feedback to those who has done the analysis and most important make it possible to se the changes the analysis does.

The flight distribution's importance as a means of supplying crucial commodities during a disruption or crisis – with main focus on the pharmaceutical supply

Anders Jacobson
Patrik Jansson

Abstract

This report contains a mapping of the different types of goods imported into Sweden by air during 2004. The process of the collection of statistical data resulted in a model. The model was developed with the purpose to make future updates easier and more accurate. Finally, the report contains a vulnerability analysis for the supply chain of pharmaceuticals in Sweden. The role of aviation was taken into consideration in the analysis.

Introduction

Today's society and its critical functions require an intact transport network in order to function. Disruptions in the transport network can result in some transports not reaching its destination. There are among these transports some that is of more or less importance to different functions and interests in the society. The ones with the most importance to the society are called critical transports, and if these transports fail to reach its destination the basic conditions needed to uphold the functions that are looked upon as necessary in our society are affected.

The definition of critical transports is hard to define. There are two different groups of transports that are known to be of greater importance than others. First, there are the types of transports that constitute a basic condition for survival including emergency transports, rescue service and food supply. Second, there are the types of transports that are of great importance for the long-term endurance of society. These transports include the health and nursing transports.

The report was assigned by the Swedish Civil Aviation Authority (SCAA). SCAA has a need of information regarding the air freight industry. The purpose is to determine whether critical transports exist within the air freight industry. In order to create opportunities for SCAA to fulfil their need of information, a study of the present situation has been done to map what is being imported by air into Sweden. The mapping, apart from documenting the content, also includes recording volumes of goods and geographic spread. The study was based on SCB's import statistics from third country, i.e. statistic material regarding trade with non EU-countries.

Model for statistical updates

The process of the collection of statistical data resulted in a model made for the SCAA. The model was developed with the purpose to make future updates easier and more accurate, and it consists of the following six steps:

- Definition of scope
- Identification of sources and operators
- Collection of data
- Valuation of data
- Correction of data
- Compilation

Vulnerability analysis

When the statistical data regarding air bound import was compiled, the tables showed that pharmaceuticals represented a considerable amount in terms of value. In addition, the transportation of pharmaceuticals is considered critical. In order to define the impact the aviation has on the pharmaceutical supply in Sweden, the entire supply chain, from production to retail, was analysed. The leading elements that affect the vulnerability of the supply chain proved to be:

- Physical conditions
- Market related conditions
- The structure of goods and information flow

Analysis results

Sweden represents a very small part of the European market and is therefore a relatively low priority by the pharmaceutical industry. A longer disruption in the air traffic can therefore cause certain problems. During an extensive crisis that involves several countries such as a pandemic, where the demand for vaccine dramatically increases, national interests may prevail. A foreign pharmaceutical producer may in such a scenario prioritise the national need before Sweden's. In case of a pandemic, the consequences could be that Sweden would not get any medicaments. In case a crisis situation would arise in Sweden on the other hand, Sweden would get high priority by foreign pharmaceutical producers. The market related conditions also determine the system's ability to handle strains. The pharmaceutical supply system in Sweden has had the same structure since the 70's and it is strongly regulated with a pharmacy monopoly and a single channel distribution. This system has obviously worked well since Apoteket AB successfully has managed to deliver pharmaceuticals to the Swedish population. Furthermore both retailers and wholesalers points out that the existing system is very safe regarding delivery fulfilment. Single channel distribution however, is not optimal in terms of vulnerability since it means that a single product only is distributed and kept in stock by one of the wholesalers. If the wholesaler can not deliver a specific product, there is no other place to get a hold of that product.

An increase of the availability of pharmaceuticals can be accomplished by an increase of pharmacies. Experiences from Norway and Iceland show that a deregulation of the pharmacy monopoly in Sweden would result in an increase of pharmacies. The deregulation would probably also affect the market structure in terms of vertical and horizontal integration. Additional research is needed to analyse these types of changes in the market structure. The research should comprise the effect the deregulation has on the pharmaceutical industry as well as the supply chain of pharmaceuticals and the health care in Sweden.

In case of a disruption in the supply chain, the availability of pharmaceuticals is limited by the stock levels. The stock levels in Sweden are determined by the producers and not by the wholesalers. This, in turn, states that the availability of pharmaceuticals in Sweden is not controlled by the Swedish government.

Conclusions

The quality of the statistic material received from SCB was, for different reasons, judged to be to low to present a fair picture of the real flow of goods. What could be said from the statistic material though, was that the goods flown support the theories that exist regarding the air freight and what is normally transported by air. The geographic spread proved to be concentrated to the three larger airports Arlanda, Landvetter and Sturup. Something that would improve the validity of the statistical data of the air bound import is to include mode of transport in the Intrastat statistics and to analyse the statistics on a higher level of detail.

The fact that the medical service, as a critical function, and the accessibility of pharmaceuticals is dependant on foreign stakeholders is remarkable.

If one sees to the Swedish pharmaceutical import, the role of the flight distribution is not crucial. A shorter disruption of air transports would not cause any problems at all since only a very small volume of the Swedish import of pharmaceuticals is transported by air. Furthermore the redundancy regarding intra-European transports is considered to be good. A cancelled air transport mission can often be carried out without any problems using a truck instead, on the assumption that the disruption has not made larger parts of the road infrastructure unusable.

Possibilities and obstacles to integrate the work with antagonistic and accident related risks – A comparison based on two consult agencies work procedures

Jon Johansson
Jane Nilsson

Abstract

The aim of this report is to investigate, on the basis of two consult agencies perspectives, what the possibilities and obstacles are to integrate the work with antagonistic and accident related risks. The report is based on two consult agencies where each agency's work procedure is represented by a risk management method. The work with accident related and antagonistic risks is analysed and evaluated compared to four different components. The components are risk management process (IEC's and FEMA's model), driving forces, education and competence, and resources to control risk management with COSO's ERM framework. On the basis of the components the authors discuss the possibilities and obstacles concerning the integration.

The results from the analysis are compared with the result from interviews with people working with risk management: The interviewed people were asked how they regard the possibilities and obstacles concerning integration of risk management methods.

Introduction

Antagonistic risks, i.e. risks related to actions made by intent, contribute to the Enterprise-wide portfolio of risk. The attitude to antagonistic risks has been changed since e.g. the attack on USA, 11 September 2001. This change results in a growing interest to include antagonistic risks when working with risk management. The authors expectations are that a coordinated management of accident related and antagonistic risks will lead to saved resources in a company.

The report is based on two consultant agencies perspectives. The two agencies are AB Ångpanneföreningen that manages accident related risks and SecMentor A/S that manages antagonistic risks. These two agencies are used as external participants to help companies in their risk management work.

Method

To be able to identify what the possibilities and obstacles are concerning integration of the two work procedures, the authors have made an analysis where the process of managing each risk are compared to each other.The analysis is based on comparison with a couple of components that the authors consider affect a company's risk management work. The components are:

- *Risk management process*, where AB Ångpanneföreningen's work procedure is represented by IEC's model to manage accident related risks and SecMentor A/S work procedure is represented by FEMA's model to manage antagonistic risks.
- *Driving forces* – the reasons why a company works with risk management.
- *Education and competence* – the education and competence of the employees working with risk management.
- *Resources to control risk management* using COSO's Enterprise Risk Management framework.

In the analysis the risk areas are compared, component by component, to make it possible for to the authors to discuss the possibilities and obstacles concerning integration of antagonistic and accident related risks.

Analysis

The analysis shows that there are some possibilities to integrate the work with accident related and antagonistic risks. The authors advocate that the course of events in a certain extent is the same between the two risks. Due to this fact they conclude that some parts of the estimation of consequence and the risk response, from IEC's and FEMA's models, are possible to integrate. The authors have however also identified some obstacles, where they believe that the work procedures, between the two risks, are too different to be integrated. For example they consider that the way of performing probability assessment is too different between antagonistic and accident related risks to be able to use the same methods. The problem with the probability assessment results in a couple of new obstacles: e.g. it can be hard to use the same measure of risk if the probability is not calculated in the same way.

Interviews

To be able to strengthen the analysis, a few phone interviews were made. The interviews were carried out with people working with risk management to find out how they regard the possibilities and problems concerning integration of the work with antagonistic and accident related risks. The interviews were also used to confirm that the components used in the analysis were essential and if the overall conclusions were reasonable.

The result from the interviews shows that the interviewed persons in a great extent are unanimous. All of them argued that there are possibilities to integrate the estimation of consequence and the risk response, in the risk management process. They also thought that all risks in a company must be managed in the same risk management system, to give the management an overall portfolio of risks. They however considered, like the authors, that the probability assessment is too different between antagonistic and accident related risks to be able to integrate the work. The validation of the components, which were used in the analysis, shows that the components considered can be regarded as essential.

Discussion

AB Ångpanneföreningen and SecMentor A/S

The objective of the report was to find integration possibilities that can lead to cooperation between the consult agencies AB Ångpanneföreningen and SecMentor A/S and their different risk management processes. The authors mean that there are possibilities for the agencies to cooperate i.e. can the consequence analysis that AB Ångpanneföreningen uses also be used by SecMentor A/S, to avoid doing one of their own. This would result in a profit in time and maybe also enhanced quality on the analysis compared to doing it by themselves. Each agency may also be able to develop their analysis by learning from each other and the way people think and work in the other area.

The result of cooperation between the agencies would result in a wider product portfolio offered to their customers with more risks considered when making a risk analysis.

A risk management framework

To be able to gather all the risks in a company and create an overall view of them, the authors recommend that all risk management should be done with the same risk management system. An overall view of the company's risks makes it possible for the decision makers to have better prestudies which help them to make better decisions because of a better foundation. In the report the COSO enterprise risk management framework have been studied. This framework was taken into consideration because this is an overall risk management system and the authors think that it's so flexible that it may be able to include both antagonistic and accident related risks.

Conclusions

When comparing the result from the analysis with the interviews some similarities and differences are detected. The authors and the interviewed people shared the same opinions about the estimation of consequence, risk response, and the

probability assessment. There are however some differences between the analysis and the result of the interviews. An example of this is that the authors considered the driving forces to be something that might cause problems while the interviewed people did not think of it as a problem.

Classification of safety instrumented systems in the process industry sector

Karin Johansson

Abstract

The result of the work is a method to assign Safety Integrity Level, SIL, to areas in the process industry. The developed method consists of three parts: screening analysis, extended HAZOP analysis, and detailed analysis. Assigning a SIL to the process is one way to handle the risk assessment and make the process adequately safe. The base of the work is the standard IEC 61511 "Functional Safety – Safety Instrumented Systems for the Process Industry Sector".

Introduction

Safety instrumented systems in the process industry have new risk profiles due to technical progress. Software failures are the most important risk factor in new electronic and programmable systems. In the old hardwired relay systems, however, hardware failures were most important. This technical progress and the resulting change in risk profiles has risen a need for safety standards. Most important to the process industry of the newly developed standards is IEC 61511 "Functional Safety – Safety Instrumented Systems for the Process Industry Sector". In Sweden it is optional to follow the standard since it, unlike in some other countries, is not required by Swedish law. (Weibull 2004)
Developing a method for Hydro Polymers to decide a suitable Safety Integrity Level, SIL, for the safety instrumented system is the purpose of this thesis project. Hydro Polymers want an effective but easy method. The personnel do not have time to learn or use complicated methods.

Risk management

Making the process inherently safer should be the first way to handle risks in process industry. Inherent safety means to make the process less dangerous by for example lowering the temperature and/or the pressure. In some cases it is also possible to exchange reactants to make the process inherently safer. All processes are not suitable for the inherent safety concept. If the concept is not applicable the next step is to install safety barriers at different levels. Safety barriers are often called layers of protection. If they are independent the expression IPL, independent protection layers, is used. Examples of protection layers used in the process industry are: basic process control system, alarms with operators response, safety instrumented system, active barriers, passive barriers, and emergency response, figure 1. (Weibull 2004)

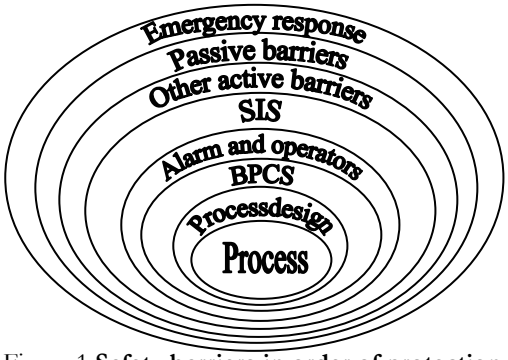


Figure 1 **Safety barriers in order of protection.**

Either reducing the probability of the scenario or reducing the consequences of the scenario reduces the risks. In reality is it not possible to eliminate all the risks; instead the risks are reduced to an acceptable or tolerable level. There are some risks that are impossible to reduce under the tolerable level but we still choose to expose us to the risk. This is because of the benefit from the activity. Risks of this type are reduced "As Low As Resonably Practical", ALARP (Wiegerinck 2002). The remaining risk is the tolerable risk for this specific application. (IEC 61511-3 2003)

Standard IEC 61511

There are three parts of standard IEC 61511:

- Part 1: Framework, Definitions, System, Hardware and Software requirements
- Part 2: Guidelines for the Application of IEC 61511-1
- Part 3: Guidelines for the Determination of the Required Safety Integrity Level

The aim of the standard IEC 61511 is to yield a safety instrumented system that can be confidently entrusted to place and/or maintain the process in a safe state. The standard states requirements for the specification, design, installation, operation, and maintenance of the safety instrumented system. (IEC 61511-1 2003)
Assigning SIL to safety instruments was first introduced in the U.S. It was introduced in Europe 1998 with the standard IEC 61508. The standard IEC 61508 includes all parts of a safety instrumented system and how to construct them, while IEC 61511 is the sector standard for the process industry. This standard only includes how to use the components. Definitions of the ranges in SIL are described in table 1. (Beckman 1998)

Table 2 Definitions of SIL

SIL	PFD	Risk reduction
4	10^{-4}-10^{-5}	10 000 – 100 000
3	10^{-3}-10^{-4}	1 000 – 10 000
2	10^{-2}-10^{-3}	100 – 1 000
1	10^{-1}-10^{-2}	10 – 100
-	$>10^{-1}$	<10

Standard IEC 61511 only states what to achieve, not how to do it.

Overview of methods

When assigning SIL to the instruments, in one part of the process, there are a number of different methods to use. The methods are divided into groups depending on how detailed they are. In this report qualitative, semi quantitative, and quantitative methods are described.
Which method to select is dependent on different factors such as: complexity of the applications, the information available, the nature of the risk, the required risk reduction, and the experience and skills of the persons available to undertake the work. (IEC 61511-3 2003)
Qualitative methods have the benefit of limited resources requirements. The ones described in the report are: corporate mandated SIL, consequence only, modified HAZOP, risk matrix, and risk graph. These methods are suitable for old processes where the experiences of the process are good. (Summers 1998)
A semi quantitative method called "Layer of Protection Analysis" is described. This method is more systematic than the qualitative methods and it is easier to document the work.
The quantitative methods are the most extensive and time-consuming methods. They are mostly used when the access to historical data is limited or if the process is complex. These methods can give more objective results than the qualitative and semi quantitative methods but there is still some subjective assessments left. Fault Tree Analysis and Financial Risk Analysis are the quantitative methods described in the report.

Developing the new method

The developed method consists of three parts:

- screening analysis
- extended HAZOP-analysis
- detailed analysis

The screening analysis is used to identify the scenarios with significant risks. Identified risks are analysed using the extended HAZOP analysis to assign SIL. If the consequences are severe or if the resulting SIL is 3, the detailed analysis is used. In figure 2 there is an overview of the different steps in the method.

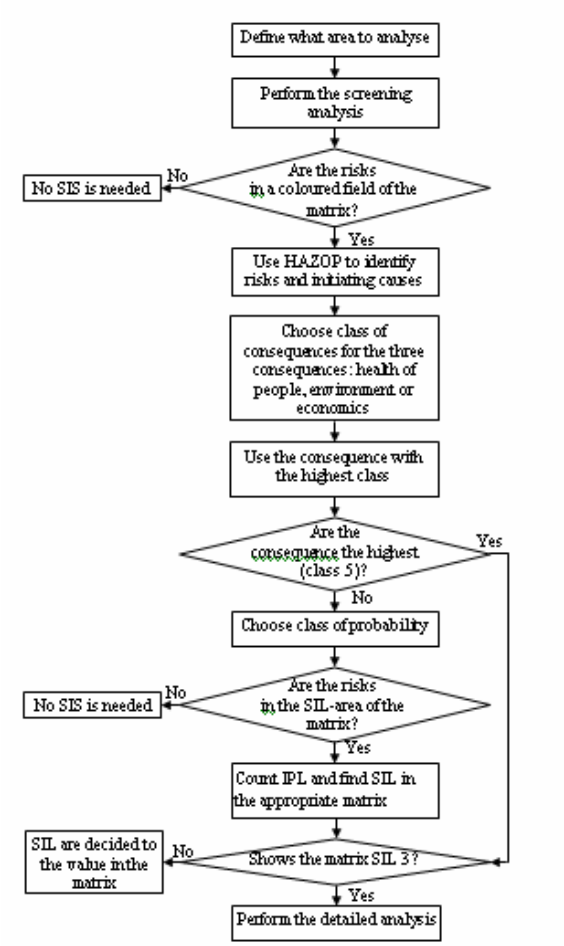


Figure 2 *Overview of the new method*

The screening method uses a matrix to classify risks. Probability and consequences are estimated on a five-degree scale. If the risk is classified in one of the coloured fields in the matrix, figure 3, the extended HAZOP analysis is used.

The extended HAZOP is like an ordinary HAZOP at the beginning but there is more than identifying risks. When performing the analysis, the IPLs already installed should not be taken into consideration. The identified risks are once again classified in a matrix. Which matrix to use is dependent on the number of available IPL. Counting IPLs are made in a simplified barrier analysis as an extension of the HAZOP analysis. If there is one IPL available the matrix to use is the one in figure 4.

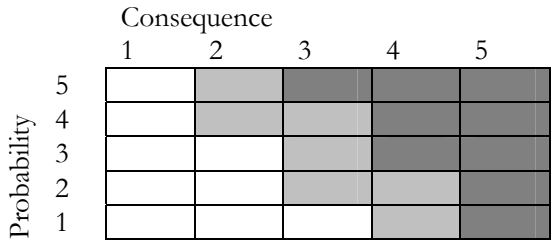


Figure 3 Screening matrix. Risks in the coloured fields need further analysis.

Probability \ Consequence	1	2	3	4	5
5	SIL 1	SIL 1	SIL 2	SIL 3	SIL 3
4			SIL 1	SIL 2	SIL 3
3			SIL 1	SIL 2	SIL 3
2				SIL 1	SIL 2
1					SIL 2

Figure 4 Matrix for SIL assignment if there is one independent protection layer.

The detailed analysis is a barrier analysis in which the probability of the unwanted scenario is analysed more carefully. The consequence classification remains the same as in the HAZOP analysis.

When modifications are made it is enough to update relevant parts of the analysis, it is not necessary to make the analysis from the beginning again. While using the method for new projects it is important to remember that risk analyses need to be made at an early stage. It is in the beginning of the project that the risks can be changed through inherent safety, without enormous costs. To change an idea is a lot cheaper than to change installed equipment. During the construction of the safety instrumented system one should remember not to make the system complex, simplicity is preferred. Complex systems are hard to overview and it is difficult to decide whether the safety standards are fulfilled or not.

Evaluating the new method

Evaluation of the new method has been done by analysing parts of the existing plant at Hydro Polymers. The chosen parts are:

- general risks at the steam boiler
- leakage from a large outdoor chlorine pipe

- overpressure in the cell room chlorine system
- a run-away reaction

As the screening analysis in the method is not new, it has not been evaluated within this work. In the evaluation of the extended HAZOP analysis focus was on the classifications of consequences and probability and the simplified barrier analysis. The complete methodology of the detailed analysis has been evaluated, as it is completely new for the company.

During the first tests of the extended HAZOP analysis the experience was that it was hard to classify the risks without considering the IPLs already installed. After a few tests the analysis team got used with the way of thinking and it became easier. The simplified barrier analysis had a few questions as well:

- What counts as an IPL?
- What area is the assigned SIL assigned to?

When tested, the detailed analysis was found complicated. There was a few questions on how to perform the analysis, but the results where good anyway. No need for major changes is foreseen at this stage. The analysis team not being familiar with the method is the most problematic aspect. As the detailed analysis is not expected to be frequently used, it is allowed to be more complex.

Abbreviations

ALARP	As Low As Reasonably Possible
BPCS	Basic Process Control System
IPL	Independent Protection Layer
PFD	Probability to Fail on Demand
SIL	Safety Integrity Level
SIS	Safety Instrumented System

References

IEC 61511-1 (2003) *Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 1: Framework, Definitions, System, Hardware and Software requirements,* IEC

IEC 61511-3 (2003) *Functional Safety – Safety Instrumented Systems for the Process Industry Sector – Part 3: Guidance for the Determination of the Required Safety Integrity Level,* IEC

Summers, A. E. (1998) *Techniques for assigning a target safety integrity level,* ISA Transactions, 37, 95-104

Weibull, B. (2004) *Säkerhetskritisk instrumentering Vad innebär IEC 61511 för processindustrin,* IPS Guide

Wiegerinck, J. A. M. (2002) *Introduction to the Risk based design of Safety Instrumented Systems for the process industry,* Proceedings of the 7th International Conference on Control, Automation, Robotics and Vision (ICARCV'02), 1383-139

Classification of process equipment – a basis for risk based maintenance

Karl Hedvall

Abstract

An important factor for the overall risk situation at manufacturing plants in general and in processing plants especially is how the maintenance work is managed. For this reason, a risk based maintenance approach is an interesting strategy for maintenance management. In this report a systematic working procedure for risk classification of processing equipment from a maintenance point of view is described. The classification system is adapted for use in complex processing plants. Preemraff Göteborg, a refinery located on Hisingen, Gothebourg, has been subject for the underlying study.

The basic idea of the classification system described in this report is that the maintenance related risk situation is used as a guidance instrument for allocating and dimensioning of the maintenance efforts at the refinery.

The system consists of:

- Risk analysis according to the FMEA-model, which has been adapted to the specific conditions at the refinery.

- Evaluation of the identified and estimated risks in concordance with the standardized risk tolerance criteria that has been worked out as a part of the system. For this, risk matrices are used. The risks are defined according to a three graded scale as tolerable, significant but tolerable or as not tolerable.

- Guidance for how the maintenance work should be carried out in regard to the risk category that the processing equipment belongs to.

Failure Mode and Effect Analysis (FMEA) is a risk analysis method based on identifying failure modes in technical systems. Trough fault tree modelling the combination of factors that result in failure in technical equipment are described and the probability of these failures can be calculated. Fault trees are constituted from logical functions, *and- & or-functions.*

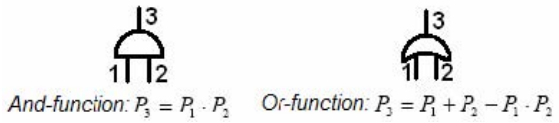


Fig. 1, Logical functions

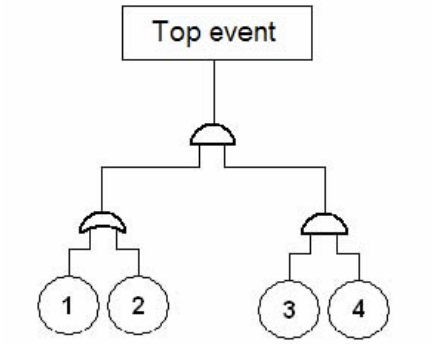


Fig.2, Example of fault tree

The Effect Analysis part of the method is based on event tree analysis where the possible effects of the identified failure modes are described. The probability of each possible consequence, or effect, of each failure mode can be calculated in the event tree.

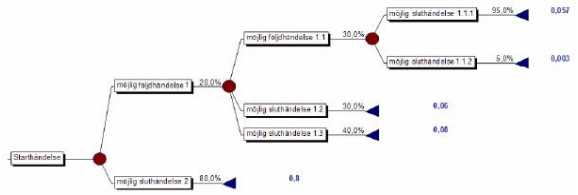


Fig. 3, Event tree

The top event from the fault tree is the starting event in the event tree.

Classification of process equipment – a basis for risk based maintenance

The risks are defined after a five graded scale regarding probability and consequence. Three consequence categories are used, these are:

- Physical injury on employees
- Environmental damage
- Direct economical loss

Each risk is plotted in to risk matrices, one for each consequence category. The company or organization defines each element in these matrices in respect to there risk tolerance (See example below).

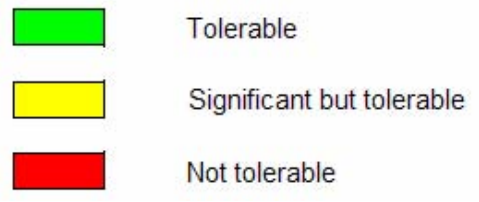


Fig. 4, Risk severity categories

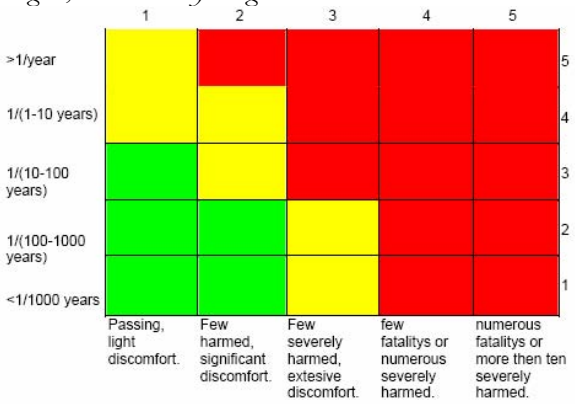


Fig. 5, Example of risk matrix with risk tolerance criteria – physical injury on employees

The maintenance program for each process equipment is then defined depending on which category it belongs to (green, yellow or red). The risk profile for equipment in the green category is considered to be tolerable and should therefore not engage a large part of the total maintenance resources. For equipment in the yellow category larger values are at stake and/or failure are considered more frequent. For this reason, this equipment is allowed to engage a larger part of the resources. For components in the red category, the risks are not tolerable, and risk reducing efforts should be carried out. For this category, a deeper analysis according to the RCMmethod (Reliability Centred Maintenance) is suggested. The method is used for optimization of the maintenance program on the analyzed component. This analysis thereby decreases the probability for failure, at least to a significant but tolerable level (yellow).

To decide which maintenance method should bee used, decision trees are used, one tree for each severity category.

The risk analysis group is constituted to contain desirable competences and key persons for a full risk analysis result and for acceptance in the organisation as a whole. The constitution of the group is depending on the nature of the analysed plant and the organizational conditions. Not only technical competences are needed. It is also important that those who are affected by the analysis result in their work are represented in the group to obtain confidence in the method and in the analysis result.

The system aims to give a good overview of the maintenance related risks at the analyzed plant. Further more, the analysis result is a good motivation for the suggested maintenance activities and as motivation for extended or decreased maintenance resources in total. Through the composition of the analysis group, a common view of the maintenance role and importance to plants in general and for Preemraff Göteborg especially are promoted. This leads to increased understanding and facilitates the management of goal conflicts.

Decision model for the food industry – how can decision makers´ values be taken into consideration?

Anna Kristensson
Annie Svensson

Abstract

The producing of safe products is very important for the food industry today due to increasing awareness of the consumers and competition in the market. To reduce the risk of pathogenic bacteria in the food industry a structured decision analysis is needed. The purpose of the thesis is to investigate which hazardous events that have occurred in the food industry, in which way these events best are described and investigate how the food industry value negative events due to the occurrence of pathogenic bacteria in products. The thesis will also present an example of how a food company can consider the value of risk in their daily work. After a review of occurred events three attributes were chosen that best described the consequences of a hazardous event in the food industry. The attributes were dead, illness and direct cost. An empirical investigation was carried out to measure decision makers´ values of risk. The quantitative part of the investigation used two methods and the result showed that dead was the most important attribute followed by illness and direct cost. The qualitative part of the investigation showed the importance of consumer confidence and a strong brand. In the next part of the thesis an example of a model for decision making was presented using the chosen attributes, the decision makers´ value of risk and the concepts of risk management.

Introduction

The producing of safe products is very important for the food industry today due to increasing awareness and competition in the market. To be able to produce safe food products a quality-system called HACCP (Hazard Analysis and Critical Control Points) is used. HACCP is a way to work to minimize health issues by supervising several critical points in the production chain. A structured decision analysis is needed to be able to produce on a high level in respect to product safety and economy. In the decision analysis the risk of bacteria occurring is evaluated in relation to the consequences for the company.

The thesis is performed in close relationship with SIK, The Swedish Institute for food and biotechnology, and Matforsk in Norway. This work is part of a Nordic cooperation project CRAN, Company Risk Assessment Network. The CRAN-network will among other things work as a discussion channel for industrial risk assessment and produce a framework for decision making in the dairy industry.

The purpose

The purpose of the thesis is first to investigate which hazardous events that have occurred in the food industry and in which way these events best are described – part A. Secondly the purpose is to investigate how the food industry value negative events due to the occurrence of pathogenic bacteria in products – part B. This information will underlie a proposal of how a food company can consider the value of risk in their daily work and in the process of risk management – part C.

Methods

Part A
To be able to fulfil the purpose the first step was to survey the occurred events in the industry and to present attributes that describes the consequences of a hazardous event in the best way. This was done by a database search, a literature search and a discussion with decision makers in the food industry.

Part B
After the presentation of attributes an investigation was carried out to measure decisions makers' values of risk. The empirical investigation is divided into two parts, one quantitative web-based part and one qualitative part with interviews. The web-based formula used two methods, Policy-capturing and swing, to measure decisions makers'

values of risk. The task of the formula was to create weights of how important each attribute is in relation to each other.

Part C
The final part was to combine the chosen attributes and the values with theories of decision making to make an example of a model for decision making in the food industry.

Results

Part A
The occurred events, from the database search, literature search and the discussion, were classified into four different types of hazards and then three attributes were chosen, dead, illness and direct cost.

Part B
The result from the web-based part in the empirical investigation showed that dead was the most important attribute even though the measures of its size were different between the two methods. In table 1 the proportions of how the decision makers valued the different attributes, dead, illness and direct cost is shown.

Total	Part 1 - regression	Part 2 – swing
Dead	84%	48%
Illness	12%	38%
Direct cost	4%	13%

Table 1. Proportion (in average) of how decision makers value the attributes.

The purpose of the interview part was to broaden the insight of the decision makers' thoughts about pathogenic bacteria. The result of the interview showed the importance of consumer confidence and a strong brand.

Part C
The model for decision making in the food industry was divided into six steps: bank of information, goals, state of factory, comparison, decision analysis and actions. It is in the decision analysis that the results from the presentation of attribute and the empirical investigation are used. In this final part risk management is discussed in terms of decision making.

In figure 1 the model for decision making in the food industry is presented.

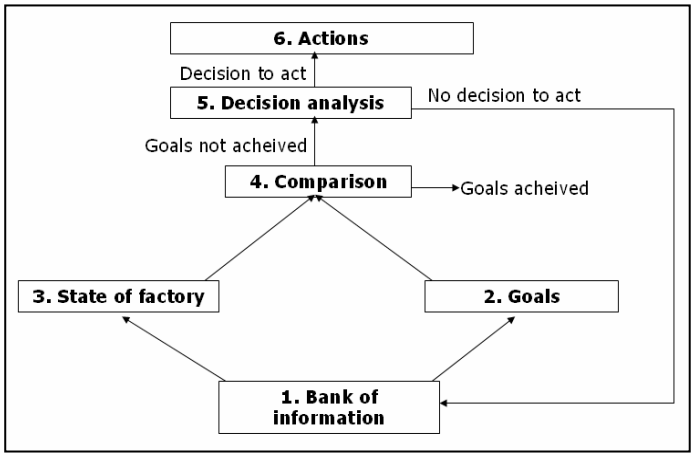


Figure 1. Model for decision making

Discussion

The result of the thesis showed three attributes where dead was the most important according to the decision makers. However the result of the two methods used in the web-based formula was different and that depends on how the decision alternatives are described. The difference was not surprising since this was widely described in the literature.

It is important to emphasize that the weights created in part B of the thesis only applies to the specific interval of the attributes. The weights can not be used in another context.

In the empirical investigation 17 decision makers were questioned. To make the results more statistically significant it would have been desirable with more than 20 persons in the investigation.

The model for decision making in part C is a simple schematic presentation. This can be done in a much more detail, for example with a complete cost benefit analysis. However this is a task for SIK or the CRAN-network to work with.

Uncertainties in fire safety design of ventilation systems

Nils Johansson

Abstract

This article deals with smoke spread via ventilation systems. The article is based on a master's thesis conducted at the University Of Lund, Sweden. One aim of the thesis has been to investigate and explain the differences in efforts to prevent smoke spread via ventilation systems in different countries. A second aim has been to investigate how frequently occurring smoke spread via ventilation systems are in Swedish buildings. A third aim has been to investigate how uncertainties in different input variables to smoke spread calculations will affect the result of a calculation. To be able to do this the most important input variables have been identified and analysed. A calculation example has also been conducted where a supply and exhaust system is analysed with an event tree and the computer program PFS.

Introduction

In almost all modern buildings in Sweden ventilation systems are used to create comfort. Usually it is not cost or space beneficial to build separate ventilation ducts from all fire compartments in a building. This means that ducts will connect different fire compartments with each other. In case of fire and if no preventive measure is taken it is therefore possible for smoke to spread between compartments. Unlike when smoke spreads through walls and joists smoke will travel further and in less time through the ventilation system.

Studied areas

This article is based on a master's thesis conducted at the University of Lund, Sweden. The thesis deals with three rather separate issues related to smoke spread via ventilation systems: regulations and accepted procedures in Sweden and abroad, occurred incidents and uncertainties in fire safety design of ventilation systems. Even though the three issues are rather separate, they all contribute to the understanding of the problem.

Codes and practise

In the first part of the thesis codes and practise in a couple of countries are studied to investigate how the problem is treated abroad and how well it is understood in Sweden compared to other countries. The following seven countries have been studied: Sweden, Norway, Denmark, Germany, England, USA and New Zealand.

There are more or less opportunities for function based fire safety design of buildings in all the study countries. It is clear in all of the studied codes that smoke is not allowed to spread between fire compartments through the ventilation system. Despite that it has come clear, during the project, that methods for analytical design of how to prevent smoke spread in ventilation system are best developed and most frequently used in Sweden. While prescriptive solutions, especially with dampers, are almost exclusively used abroad. That analytical methods has been developed in Sweden is partly regarded as a result of the Swedish codes, which in greater extent than codes in other countries, gives opportunities for analytical solutions such as keeping fans running.

It has been hard to compare the different countries since it is difficult to determine used practise. But a simple comparison, based on the study of codes and guides, concludes that Swedish codes require the lowest level of safety of all the studied countries. This can be a result of higher awareness of the problem in Sweden. If the higher awareness is due to conducted research or something else is however hard to conclude.

In the thesis a questionnaire has been conducted. Most of the respondents in the questionnaire believed that engineers in Sweden are better than engineers in other countries in Europe and the world in developing good systems to avoid smoke spread through ventilation systems. However some of the respondents claimed that the theory is well understood but that the practical solutions in many cases are insufficient. This claim hints that the function based alternative not only creates opportunities for good and appropriate solutions

but also for mistakes and wrong doing. Review and control of analytical solutions is therefore a prerequisite for the function based opportunity.

Occurred incidents

It is hard to determine how serious and frequently occurring the problem with smoke spread through ventilation systems really is. The second part of the master's thesis has therefore been dealing with occurred accidents in Sweden. It has been done by contacting around twenty rescue services in Sweden and through the earlier mentioned questionnaire.

The study has not revealed any incidents in correctly designed system with fans in operation during fire. However older systems that are designed after the so called pressure loss method seems to be a problem. How aware real estate owners and municipals are about this problem has not been studied further but is something that definitely has to be done in the future.

On the basis of the study of occurred incidents it does not seam that smoke spread through the ventilation system constitutes a great danger in a fire in relation to other consequence. But to be able strengthen this conclusion incidents needs to be reported and documented. And the documentation must be taken care of so the experience can be used to develop even better and more secure fire safety solutions.

Uncertainties in design

Reliable calculations on smoke spread through ventilation systems demands great knowledge in the system of interest and in the building that the system will be installed in. If this knowledge is not available uncertainties will arise in the subjective estimates that have to be made. And if no concern is taken to inputs that can vary the calculations will be deterministic and even more uncertain.

In the third and largest part of the thesis a risk based method is used to investigate the risk of smoke spread in a supply and exhaust system designed for fans in operation. To be able to do this an analysis of some important input variables had to be done. This analysis shows that there are large uncertainties due to both lack of knowledge and variation. Knowledge uncertainties could be reduced for some of the variables with the help of statistics and earlier studies. However there is still a great need for subjectivity in the estimation of the studied variables which is considered to create problems.

An event tree in combination with the computer program PFS, where the consequence was calculated, was considered to be the most appropriate method for the study. Two analysis's, with and without fire safety measure, of the ventilation system was conducted. The risk based method appeared to work fine and the results could be illustrated well. The results showed that there was an extensive smoke spread when the fire safety measure was not used. The results also showed that the fire safety measure worked fine but that the probability of smoke spread still was significant. This illustrates that, in contrast to the study of occurred incidents, smoke spread via ventilation systems can be a big problem in a fire even though preventive measures are taken.

In the thesis a discussion regarding acceptance criteria for smoke spread through ventilation systems has been conducted. The conclusion of this discussion is that no recommendation of acceptable criteria can be done presently. Due to this it is considered important to develop written rules or a standard of how fire safety design of ventilation systems should be done and how uncertainties should be treated.

Conclusions

The following conclusions could be drawn from the thesis:

- Calculation procedures and computer programs for design solutions with fans in operation are considered to be best developed in Sweden.
- Swedish codes require the lowest level of safety of all the studied countries codes. This creates a demand for review and control of analytical solutions.
- Incidents where smoke spreads through ventilation systems can be found in Sweden. But in all found cases it is due to a poor design or the use of the earlier recommended pressure loss method.
- Rather few incidents are reported where smoke spreads through ventilation systems. A reason for this can be that the consequence of smoke

spread via ventilation systems is little in relation to other consequence in a fire. An effect of this can be that the problem is neglected in many incident reports conducted by the fire service.

Risk based methods can be used in fire safety design of ventilation systems. However the input variables are in many cases uncertain and efforts has to be made to investigate them further.

Since the required level of safety is low in Sweden compared to other countries it is considered important to develop written rules or a standard of how fire safety design of ventilation systems should be done and how uncertainties should be treated.

Vulnerability analysis of an infrastructural network – Using network theories to perform vulnerability analysis of complex networks

Tobias Salomonsson
Mikael Schéele

Abstract

During the last few years network theories have been introduced as a new scientific research field and many articles on the subject have been published. The scoop of this work is to investigate the possibility to perform vulnerability analyze on infrastructure network, by using paraphernalia gathered from network theories. The result shows that network theories should be a valuable compliment to vulnerability analysis performed on complex networks. Finally there is a suggestion on further studies in the field of network theories.

Introduction

The thesis represents the author's Master's thesis in Risk Management at Lund University.

During the last few years network theories have been introduced as a new scientific research field and many articles on the subject have been published. The research is building on a long tradition of network analysis in sociology and anthropology and an even longer history of graph theory in discrete mathematics (Watts, 2004). It has been shown to be applicable in such different fields as power grids, cell biology and social networks.

Vulnerability in complex networks

The society becomes more and more reliant of complex networks. As an example a computer network can be mentioned, which is dependent of the power grid, which both are complex networks. The definition of vulnerability used in this work is:

> *"Vulnerability characterize how much and how serious a system affects by an incident. The extent of vulnerability is decided by the ability to anticipate, handle, resist and recover from the incident." (Risk och sårbarhetsanalyser - Vägledning till statliga myndigheter* (2003))

To secure the function of these different networks, vulnerability analysis have to be performed. This work examines the possibility to use network theories for vulnerability analysis of complex networks.

The "New" science of networks

In an attempt to facilitate for the reader to understand the concepts behind network theories, a model network has been created. The network is taken from the world of sports, a formation in soccer. The formation is called 3-5-2 and is presented in Figure. The lines between the players show how they can pass the ball. The players in the team are vertices and the possible way to pass the ball between the players, are links. The degree of a vertex is described as the number of links leading to and from the vertex. Thus is the degree of player number 9, six and for player number 2, two.

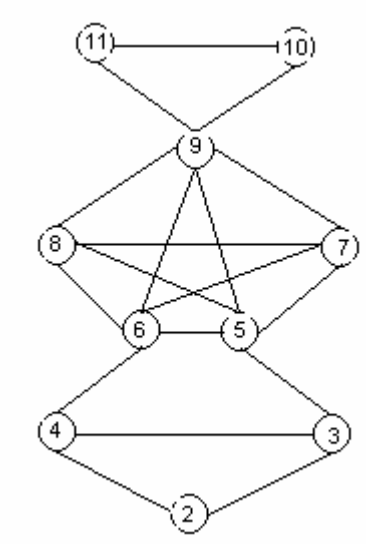


Figure 1 *A soccer team*

Real networks usually contain groups where many nodes are connected to each other (Strogatz & Watts, 1998). When a vertex's neighbor is connected to each other, the vertex has a high local cluster coefficient. The cluster coefficient is calculated by using the equation below (Holme & Kim, 2002):

$$C_i = \frac{2E}{(k_i - 1)k_i},$$

where k_i is the degree of the vertex and E is how many pair of vertices a vertex is connected to. Number 5 is connected to number 3, 6, 7, 8 and 9. These players can create six different pairs. Hence, is the cluster coefficient for player number 5, 0,6. By calculating the average of the vertices cluster coefficient the cluster coefficient of the whole network can be determined.

The degree and the cluster coefficient are two possible ways to describe the topology of a network, but there are of course other concepts that can be used, like path length. The path length describes the distance between two different nodes in the network. Thus, the path length between player number 2 and player number 11, is 4.

The power grid

The network examined in this report is a power grid. The power grid contains 961 vertices and 1017 links. The power grid has 21 752 subscribers. The power grid contains six generators, which supplies six subnets with power. Using a computer software called NetCalc, created by PhD Henrik Johansson, simulations on the power grid has been made. Simulations where performed on the whole power grid as well as on the six subnets. Two strategies have been used for the simulations. One strategy has been to attack the nodes with highest degree, the other strategy has been to randomly attack vertices or links.

The two strategies chosen are supposed to describe attacks due to acts of terror as well as attacks due to whether. The objective of an act of terror is believed to do as much damage as possible. Therefore it is believed that the terrorist will attack a node in the network that has a high degree. A power grid will also be subject of random attacks. These attacks can, for example, be due to bad maintenance or as mentioned above, whether conditions.

When vertices with the highest degree where attacked, 95% of the subscribers had lost its power after only 5% of the vertices had been eliminated. This happened because the vertices with the highest degree also often where the generators. To see how the power grid reacted when the generators could not be eliminated new simulations was performed. The result showed that after 5% of the vertices had been eliminated 35% of the subscribers had been lost.

When the vertices where attacked randomly (the generators could be eliminated) fewer subscribers had lost its power when the same percentage of vertices had been eliminated, compared to the attacks on the vertices with highest degree.

Conclusion

The subnet that loses the most subscribers, when attacking the vertices with highest degree, also loses the most subscribers when the network is attacked randomly. When comparing these result to actual statistics on interruption in the power providing shows the same conclusion. Although these report contains uncertainties it is considered that more studies on using network theories to perform vulnerability analysis of complex networks should be done.

During the writing of this report new questions have been raised. These new questions have not been able to be examined in this report but have been presented in the work. Hopefully can someone pick up where we left off and explore new aids to perform vulnerability analysis on complex networks.

References

Krisberedskapsmyndigheten (2003) *Risk- och sårbarhetsanalyser – Vägledning för statliga myndigheter* Krisberedskapsmyndigheten Stockholm

Watts, Duncan J., & Strogatz, Steven (1998) Collective dynamics of ”small-world” networks, *Nature* 393:440.

Dupont Chemosweds way of working with a consequence analysis

Olof Axelsson

Abstract

Risk management is a very important ingredient in how to run a company. Therefore risk acessment of the processes in the company is very important. Dupont Chemoswed is very aware of this factor and has therefore asked for a consequence analysis. This report is the result of this analyse. The report also investigates Dupont Chemosweds way of working with consequence analysis and gives an advice for how the company can improve their risk management work.

Disposition

The report can be divided into two parts. The first part contains a consequence analysis for the company Dupont Chemosweds factory that is located in Malmö city to investigate the consequences of a spread of a toxic substance or an explosion in one of the production halls. The second part focus on the risk management for the company based on how the company has being working on the consequence analysis.

Background

The factory is making medicine substances. The processes demand different types of solvent, which means that the substances must be held at the facility. This handling results in a various amounts of risks that the company must manage. One way has been this report that can be divided into three chapters. The report discusses two big risks namely the fact that an explosion will occur in some one of the four process locals or an uncontrolled discharge of one of the solvents.

Method

The writer has together with the company's executive team and supervisors from the Swedish Department of Fire Safety Engineering discussed different scenarios for which the author should investigate. The supervisor on the company and the writer has then together made a list of the solvents that is interesting for the analysis. The solvents have then been simulated in the for the report current model for spreading solvents and the impact of an explosion with the solvents in the process locals. For the calculations and simulations there have then been an uncertainty- and sensitivetyanalysis carried out.

To carry out the simulations a program called SLABVIEW was used. The program was developed in the USA and was build from the SLAB MODEL.

Results

When making the explosion calculates it became clear that the factory would sustain structural damage if an explosion should occur. This is the fact for an explosion in every process local. Further more it is shown that for a release of a solvent there is a possibility that the nearby compartments will experience harmful concentrations. Figure 1 shows the distances that the solvents will reach the KTV-value that is defined in the report. Since the company only have requested an investigation of the consequences and not the probability of occurrence there will be no suggestions of solutions for the company how they can minimise their risk.

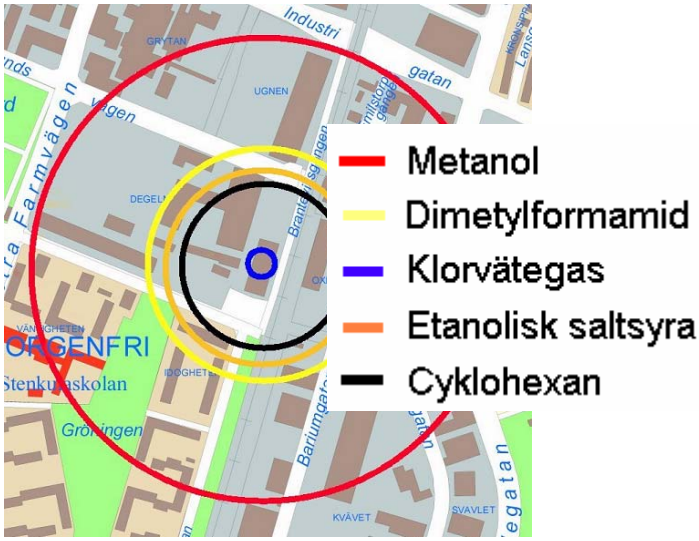


Figure 1

How is the company managing their risks?

About the study of the company's risk management the author analysed their work from viewing two models. From these two

models the writer has discussed the company's risk management proclaiming that the need to involve their employees more than today.

Figure 2 and 3 shows Argyris method for a learning company and Kolb´s circle of learning.

Figure 2

Figure 3

The result of the report is thought to be the ground for a continues discussion within the company of how the consequences that has been analysed can be reduced and if the suggestions be economically defended. Furthermore the author hope that the result of the study of the company's risk management will mean that a discussion will start about how the company can be better when working with consequence- and risk analyses, this to continue to be one of the best company's in the word in risk management.

Simplified human exposure assessment of chemicals with the help of intake fraction?

Christina Björkdahl

Abstract

The concept of intake fraction (iF) relates the emitted amount of a particular chemical to the subsequent human intake of that substance. Intake fractions have been calculated for more than 300 substances, spanning a range of up to seven orders of magnitude. It has furthermore been suggested that intake fractions can be estimated based on a few properties of the chemical. In this literature study the following two questions are analysed and discussed: Can this type of relationships be used for simplified human exposure assessment? Does high total production volume of a chemical imply high human exposure? It is concluded that variability and uncertainty in the estimated intake fractions is considerable, implying that the concept needs further development before it can be used for simplified exposure analysis in the regulatory context. It is furthermore concluded that there seem to be a positive correlation between the amount of a chemical emitted into the environment and the magnitude of human exposure to that particular substances. This does however not imply that a high total production volume of a chemical necessarily will result in high human exposure.

Introduction

Between 30 000 and 70 000 chemical substances are available on the commercial market in the European Union. /1/ The substances are used for a variety of applications and people are exposed to a multitude of different chemicals on a regular basis. To prevent unnecessary risk to humans from these chemicals require regulations. In the European Union chemicals are currently being regulated according to if the are "existing" substances (existed on the market before 1981), "new" chemicals (chemicals put on the European market after 1981) and how they are classified and labelled. The "existing" and "new" substances are to be risk assessed by authorities in the EU. The more than 100 000 "existing" substances are to be risk assessed according to priority lists. This has proven to be a slow and resource intensive process. /2/

Currently a new regulation of chemicals within the EU is being developed called REACH (Registration, Evaluation, Authorization and restriction of Chemicals). REACH covers both "new" and "existing" chemicals and the regulation is based on the annual production volume of the chemical. Similar to the old system high volume chemicals are prioritised in the way that more data are required than for low volume chemicals. /1/ This prioritisation of high volume chemicals is based on the assumption that the higher production volume the higher exposure and thus higher risk. This is a major simplification since exposure is dependent on several factors including the release of the chemical into the environment, its transportation, transformation and fate in various media and that contact with individuals actually occur. The risk is furthermore determined by a combination of (1) the exposure, (2) the chemical's inherent properties (such as its reactivity) and (3) the characteristics and susceptibility of the exposed individuals.

With the introduction of REACH the responsibility of performing exposure assessments and risk assessments is shifted from the authorities to manufacturers and importers of chemicals. However, in many small and medium sized companies the proper expertise to use a complex exposure and risk assessment tool like EUSES is lacking. /3/ This is expected to be a problem and therefore there exists a need to develop simplified assessments tools.

Intake fraction

A group of researchers have developed the concept of intake fraction and used it to derive empirical relationships that could potentially simplify exposure assessments of chemicals. Intake fraction (iF) is defined as the fraction of chemical mass emitted into the environment that eventually passes into a member of the population through inhalation, ingestion or dermal exposure and can be calculated according to the equation given below: /4/

$$iF = \frac{\sum_{people,time} \text{mass intake of pollutant by an individual (mass)}}{\text{mass released into the environment (mass)}}$$

The concept of intake fraction was first discussed in the beginning of the 21:th century /4/ but similar concepts, linking source-to-intake, have existed for more than twenty years and one reason for developing the concept of intake fraction was to unify this multitude of concepts.

It has been suggested that intake fraction can be estimated based on a few properties of the chemical studied /5/.
Intake fractions for more than 300 substances have been calculated and together they span a range of up to seven orders of magnitude. /5/ If these values are accurate it implies that there can be significant differences in exposure between different chemicals with similar emission magnitude.

Purpose and method

In this article the results of a literature study, scrutinising available research and possible methods to calculate intake fraction, is reported. The literature study also included studying the factors that potentially can influence the human exposure of chemicals.

The ultimate purpose of this literature study is to contribute to insights that can serve as an input to a science-based discussion and analysis of the following two questions:

Can empirical relationships – like intake fraction – be used to simplify exposure assessments?
Does high volume of a chemical ultimately result in a high human exposure?

The search for relevant literature was performed by using the databases Cambridge Scientific Abstracts, SciFinder Scholar, Google, an Internet based search engine, and Elin@Lund, Electronic Library Information Navigator available at the Lund University Libraries. It also included personal communications with exposure assessment experts, Stellan Fischer at the Swedish National Chemicals Inspectorate, and Gunnar Bengtsson former director general of the Swedish National Chemicals Inspectorate.

Results

Eleven scientific articles have been published, prior to this article's completion, that report calculated intake fractions for a variety of chemicals ranging from $1.9 \cdot 10^{-10}$ /5/ to $1.1 \cdot 10^{-2}$ /6/.

Most of the studies used different kinds of models to estimate intake fractions. The most widely used model was the air dispersion model CALPUFF. Other models used were CalTOX, IMPACT 2002, a sources-receptor matrix model, and a Mackay type level III multimedia fate model with a food chain model in succession.
Measured levels of chemicals have also been used when estimating intake fractions, although it usually involved some type of extrapolation or modelling in order to calculate the intake fraction. /7/

An intake fraction interval ranging from 10^{-10} to 10^{-3} was calculated by Bennett et al. (2002) /5/. In this study a uniform population density was assumed.

Other studies showed that for dioxins this assumption of a uniform population density can be a sufficient approximation but for other chemicals spatial variance could be important. /6,8/ The results from another study showed that the use of continentally averaged parameters for population density and food production provided an accurate estimate of the median intake fraction calculated for emissions in individual regions, however the intake fraction could range from this median by up to 3 orders of magnitude, especially for chemicals transferred through foods. /9/ When comparing spatial and a-spatial model predictions with measurements the spatial model was seen to predict higher concentration that was closer to monitored values. /6/ This indicates that a spatial model should be used to not underestimate calculated intake fractions.

Human exposure to chemicals is influenced by a variety of factors including properties of the source, the physico-chemical properties of the chemical, the characteristics of the media, transformation processes and factors specifically related to human intake.

In the study by Bennett, et al. (2002) /5/ empirical relationships were derived for

predicting intake fraction based on half-life, K_{ow}, and K_{aw}. These parameters are some of the parameters that contribute significantly to the uncertainty in exposure estimates. Especially half-life, which is the parameter that usually has the highest standard deviation and thus is one of the most uncertain parameters. /10/

Discussion and conclusions

This wide range of intake fractions calculated so far implies that high emission volume is not a good indicator of human exposure since emission of 1 000 tonnes of one chemical with an intake fraction of $1 \cdot 10^{-9}$ can result in the same intake as emission of 1 kg of a chemical with an intake fraction of $1 \cdot 10^{-3}$. This implication is valid if the estimations are accurate and if there in fact is a linear relationship between intake and emission.

A linear relationship can be assumed when transportation processes, diffusion and advection, are linear with concentration and when transformation processes, such as photolysis, hydrolysis and biodegradation can be well approximated as linear and first order. This has been seen to be a reasonable estimation when validating multimedia models against measured concentrations. However it is only suitable for low concentrations of a substance and for long time scales. /11/

A high volume of a chemical does thus not always result in a high human exposure since exposure is dependent on several factors including production processes, pathways, and use patterns. However the higher emitted volume of a chemical into the environment the higher the exposure of humans will be for that particular substance, this is based on the assumption that chemical exposure can be considered to be linear with concentration when considering chemicals that is released to the environment.

The conclusions of this study is that the methods used so far for calculating intake fraction relationships can not be used for simplifying exposure assessments for new chemicals. Further research is recommended to investigate which are the most influential determinants of human exposure. It is proposed that this research initially focus on investigating (1) the importance of population density, (2) the importance of where food is produced relative to emission source, and (3) the influence of K_{ow} (octanol-water partitioning coefficient), K_{aw} (air-water partitioning coefficient) and half-life. Available relationships are based on K_{ow}, K_{aw}, and half-life. Half-life is one of the most uncertain parameters used in multimedia modelling and it is questionable if relationships based on this parameter are useful since they are likely to be highly uncertain.

If further research proves it possible to obtain a more accurate estimation of the span of intake fractions, the concept may have the potential to be used to identify chemicals that can result in a high human exposure although they are not produced or imported in high volumes. This requires that calculated generalisable intake fractions are available for a multitude of chemicals.

It is furthermore important to remember that exposure can occur not only through the environment but also through more direct ways in the form of consumer products and the working environment. It is possible to calculate intake fractions for these scenarios also, but the generalisability and usefulness of these calculations would need to be further investigated.

The applicability of the concept for risk assessments will furthermore be limited in the way that it is most appropriate for chemicals, whose effects on human health show no dependencies on intake dosage rate, no thresholds between dose and effect and proportionality to cumulative exposure.

References

/1/ Hansson, S. H., Rudén, C. (editors), (2004) Better chemicals control within reach. US-AB Universitetsservice US AB, Stockholm.

/2/ Commission of the European Communities (2001) WHITE PAPER. Strategy for future Chemicals policy. (presented by the commission) Brussels. Available at: http://www.europa.eu.int/comm/environment/chemicals/0188_en.pdf

/3/ Fischer, S. personal correspondence: (2004-09-09)

/4/ Bennett, D. H., McKone, T. H., Evans, J. S., Nazaroff, W. W., Margni, M. D., Jolliet, O., Smith, K. R., (2002) Defining Intake Fraction. Environmental science & technology, 207A-211A.

/5/ Bennett, D. H., Margni, M. D., McKone, T. E., Jolliet, O. (2002) Intake Fraction for Multimedia Pollutants: A Tool for Life Cycle Analysis and Comparative Risk Assessment. Risk Analysis, Vol. 22, No. 5, 905-918.

/6/ Margni, M., Pennington, D. W., Amman, C., Jolliet, O. (2004) Evaluating multimedia/multipathway model intake fraction estimates using POP emission and monitoring data. Environmental Pollution 128, 263-277.

/7/ Björkdahl, C. (2004) Simplified human exposure assessment of chemicals with the help of intake fraction? Department of Fire Safety Engineering, Lund University, Report 5150, Lund

/8/ Lobscheid, A. B., Maddalena, R. L., McKone, T. E. (2004) Contribution of locally grown foods in cumulative exposure assessments. Journal of Exposure Analysis and Environmental Epidemiology 14, 60-73.

/9/ MacLeod, M., Bennett, D. H., Perem, M., Maddalena, R. L., McKone, T. E., Mackay, D. (2004) Dependence of intake fraction on release location in a multi-media framework: A case study of four contaminants in North America. (Abstract) Accepted for publication in the Journal of Industrial Ecology, July, 2004.

/10/ Webster, E., Mackay, D. (2003) Defining Uncertainty and Variability in Environmental Fate Models. Canadian Environmental Modelling Centre. Canada. (CEMC Report No. 200301) Available at: http://www.trentu.ca{cemc/CEMC200301.pdf

/11/ McKone. T. E. personal correspondence: (2004-09-04)

Risk analysis of turbine building number 3 at Ringhals nuclear power plant

Ola Cederfeldt
Henric Svensson

Abstract

The aim of this report was to identify and analyse components and scenarios that could lead to oil fires in turbine building 3 at Ringhals nuclear power plant with the help of a study of fires in turbine buildings, interviews with experts at Ringhals and a statistical analysis of reported oil leakage. Consequence calculations were also conducted in order to see if the safety ambitions for the turbine building could be maintained during a pool fire. The reasons why the report focused on oil fires in the turbine buildings are that international accident statistics have shown that fires in turbine building can lead to severe consequences and that oil is the major fire hazard in the turbine building. The main identified problem areas were spontaneous ignition because of autoxidation, vibrations from the turbines that for example can lead to turbine blade failure, high pressure and high temperature in the oil systems. The purpose with the report was also to suggest solutions on how to minimize identified risks regarding oil fires.

This report was initiated by an ambition to increase the fire safety of turbine building number 3 at Ringhals nuclear power plant. Turbine building fires can lead to substantial consequences and according to international accident statistics a majority of nuclear power plant fires have their origin in the turbine building.

Considerable amounts of oil are used for lubrication etcetera in turbine building number 3 at Ringhals nuclear power plant. Hence, this report will mainly focus on hazards related to oil fires. This report will exclusively focus on property loss prevention, explicitly no consideration has been taken to neither environmental nor health issues. In view of the preceding line of argument the purpose of this report has been to identify and scrutinize components and scenarios, which may cause oil fires in turbine building number 3. Furthermore the purpose has been to elucidate if the safety ambition for the turbine building can be maintained in case of fire and to suggest solutions on how to minimize identified risks regarding oil fires.

In order to fulfill the purpose of this report, three different types of methods were used; descriptive comparison, interviews and quantification.

The descriptive comparison comprised of a study of available documented fire accidents in turbine buildings in nuclear power plants all around the world and a qualitative discussion about each fire accident's relevance for turbine building number 3 at Ringhals nuclear power plant. Since there was a risk that scenarios, which could lead to fire, was overlooked in the descriptive comparison, interviews were conducted with experts at different levels at Ringhals. In addition, a statistical quantification was made related to critical components in turbine building number 3 at Ringhals nuclear power plant with help of oil leakage reports.

The different problem areas that were identified in the descriptive comparison, the interviews and the statistical quantification, were then evaluated in a problem analysis. This analysis was conducted in order to clarify the risks regarding oil fires in the turbine building. The problem analysis proved the need for an additional quantification with consequence calculations for those scenarios that can lead to large consequences and are difficult to quantify statistically. The consequence calculations were conducted with help of the computer software FREIA (FiRe and ExplosIon hazard Analysis).

The consequence analysis and the problem analysis showed that there are several oil fire risks in turbine building number 3 at Ringhals nuclear power plant. The risks that were identified are spontaneous ignition because of autoxidation, vibrations from the turbines that for example can lead to turbine blade failure or rotor failure, to high pressure and to high temperature in the oil systems, dirt in the oil lubrication system and human parapraxias.

In order to reduce the identified oil fire risks the following action programme has been suggested:

- First priority is an increase and an improvement of the sprinkler system and oil channels, construction of oil spill zones and fire proofing of the oil tank 441 T1.

- The oil separator has frequent oil leaks and its reliability should be improved, alternatively the oil separator should be moved out from the turbine building.

- Most of the oil leakages in the turbine building are due to Emeto couplings according to internal leakage statistics from Ringhals. Distinct routines for handling of these couplings should be established and they should be replaced by more reliable couplings, as the Emeto couplings are worn out.

- At level +107 and at level +115 oil deflecting screens should be installed in order to prevent oil from spaying on to hot components and other non desirable locations.

- Fire proof separation, in shape of a wall, between turbine system 31 and 32 should be considered in order to prevent fires from spreading from one turbine system to the other.

- Ringhals management should see to it that knowledge feedback works. Some key personnel have during their employment at Ringhals obtained extensive and invaluable knowledge about the turbines and its systems. It is important that this knowledge doesn't go to waste.

- A preventive way of thinking should exist in order to achieve a good safety culture. Proactive management of risk and preventive measures are always preferred over reactive measures. Unfortunately most of the work with replacing components etcetera in the turbine building is done when errors already have occurred.

- The oil pipes in the turbine building should be welded or alternatively placed in drainage pipes.

- Cables should be placed in cable trays of steel with a certain fire resistance. Important control and power cables should not be located in the vicinity of locations where to fire load is or can become high, for example the oil spill zones.

- Routines for avoiding damage of the insulation and the cover of the steam pipes during work in the turbine building should be established.

- The lube oil system pumps out more oil if the pressure in the system drops in order to maintain the system pressure. This can potentially lead to a higher fire load if a leakage occurs. Because of this, routines for lube oil system drainage should be established.

Risk Analysis and a Study of Risk Awareness and Risk Communication, Concerning Dust Explosions, at LEAF Gävle

Tobias Dahl Hansson

Abstract

The purpose of this report is to study the risk of dust explosions at Leaf Sverige, a candy manufacturing plant in Gävle, Sweden. The risk analysis was conducted with a preliminary hazard analysis (PHA) and event trees. The analysis focuses only on the risk posed to employees and material damages at the plant. No third person injuries have been considered. Another purpose of this report is to study risk awareness and risk communication concerning dust explosions. The awareness study was conducted with a questionnaire. The communication part of this report was done by a literature study and focuses on communication from management to employees. This report also presents a communication model specific to dust explosion awareness and risk information to staff at dust handling plants.

Introduction

Dust explosions are a relatively unexplored science field. There is currently a lack of statistics and models to quantify risk calculations. [1] The awareness of the dust explosion risk is also very low. Many dust handling companies seem to have very little knowledge about the risk or they simply ignore it.[2] The work on this report was initiated by Daniel Norman, Technical manager at Leaf Sverige. He realized that the company did not know much about this particular risk and wanted to address and correct the situation.

The report focuses on three parts of the dust explosion risk at Leaf Sverige´s factory in Gävle: a risk analysis to estimate the risk posed by dust explosions, a survey of the dust explosion awareness among the employees at the plant, and finally, the creation of a communication model specific for a the internal communication of the risk of dust explosions in a company.

Risk analysis

The risk analysis was initiated with a three-week visit to the factory in Gävle where a Preliminary Hazard Analysis was conducted. The PHA resulted in a subjective ranking of the different dust explosion hazards. The result was presented in two different risk matrixes: one for health and one for economics.

The worst scenarios, or more correctly, the scenarios contributing the most to the risk, were then further investigated. Consequences were calculated for the explosions using empirical equations [3][4]. Dust explosion frequencies were estimated and event trees were used to calculate the estimated number of deaths and injuries as well as the estimated economic damage.

The quantification of the scenarios resulted in estimated values of about one injury in 175 years and one death due to dust explosions once every 2500 years. The annual economic damage due to dust explosions was estimated to be € 6000.

Uncertainty analysis

An uncertainty analysis was conducted on the dust explosion scenarios in the moulding line hall because the scenarios in this area contributed the most to the total risk.

The consequence calculations and the estimation of the branch probabilities in the event trees showed to contribute very little to the uncertainties. On the other hand, the estimation of the dust explosion frequencies showed to be very uncertain. The uncertainty analysis showed, for example, that there will be one death in the moulding line hall due to dust explosions between once in 60 years to once 200,000 years.

This is a very large uncertainty. In fact, considering that the uncertainly is so high, the calculated values cannot be used as the basis for recommended actions. One thing that is worth mentioning is that the average quantified values correspond in rank to the estimations done in the PHA.

Therefore, the recommended actions are based on a few different things. For instance, some dry powder process equipments are incorrectly

constructed; an example of this is that some explosion release panels are directed to the inside. The company needs to correct this. Other recommended actions are based on the consequence calculations. The consequences of an explosion would just be too large; an example of this is an explosion in the manual drageé. The probability of a secondary explosion is very high due to large dust deposits. Improved housekeeping is the recommended action in this case.

The majority of recommended actions are, however, not technical installations and rebuilding process equipment, but rather an improved communication and learning culture at the company.

Dust explosion awareness

Most dust explosions occur because of human error and not technical error [5], and because of this, it is important that employees at dust handling plants have enough knowledge.

A dust explosion awareness survey was conducted at the plant. The aim of this study was to find out how high the knowledge and awareness about dust explosions is among the employees.

The results showed that the awareness was very low. Many employees had not even heard of the phenomenon dust explosions.

The maintenance crew seemed to have somewhat more knowledge about dust explosions than the operators, but it must be said that both groups have too little knowledge about dust explosions. Very few of the respondents even knew which of the dusts/powders at Leaf could cause an explosion. The company needs to improve this with good dust explosion communication.

Risk communication

Most available risk communication models and research is aimed at the communication between authorities and companies to a broad public. There is very little literature on risk communication within a company. The models available are, however, not useless. Portions of available communication models and literature were used to construct a risk communication model specific to the communication of the risk of dust explosions within a powder handling company. The model is schematically described in Figure 1.

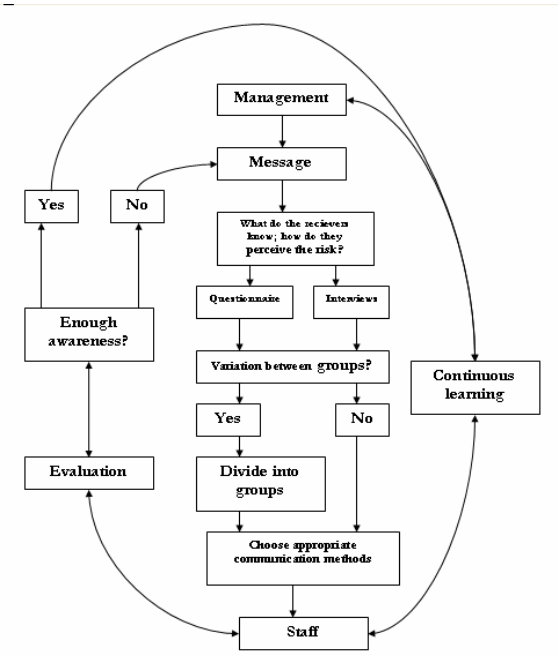


Figure 1. Schematic description of the communication model.

The communication model focuses on finding out what the staff knows and then teaching them what they do not know but need to. There should also be continuous communication between the management and the employees.

One of the most important parts of the model is the continuous learning. A more detailed look at the continuous learning is presented in Figure 2.

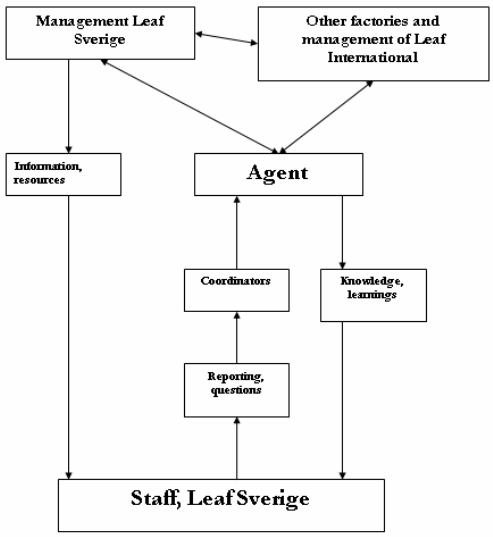


Figure 2. A closer look at the continuous learning.

The continuous learning is very intertwined with continuous reporting. The staff needs to report accidents, incidents and damages in an effective way. For this to work, the company must provide easy ways and standards for reporting.

The introduction of an agent is very important. The agent has a lot of responsibility for ensuring that the organization learns from previous mistakes. The agent should make sure that the employees report problems, and he should compile the reports and draw conclusions from the accidents and incidents, as well as make sure that the whole organization learns from the findings.

References

[1] Eckhoff, Rolf K. *Dust Explosions in the process industries*. Third edition. Burlington (2003). ISBN: 0-7506-7602-7

[2] Mitchell, Doug. *Industrial Dust Explosions*. In Global Cosmetic Industry. Apr (2002) pg.54

[3] Guidelines for Consequence Analysis of Chemical Releases. Center for Chemical Process Safety of the American Institute of Chemical Engineers (1999)

[4] Barton John. *Dust explosion prevention and protection*. IChemE (2002). ISBN: 0 85295 410 7

[5] Johnsson Per. *Förbränningsexplosioner (Tillbud och olyckor 2003-2005)* Arbetsmiljöverket (2005 June 20)

Valuation of a disasters impact on the environment

Anna-Karin Davidsson
Andreas Linde

Abstract

When a disaster occurs the main focus is on the loss of human lives. This work focuses on how people value the consequences a disaster can have on the environment. This has been done by formulating attributes and performing an empirical study. Attributes are here defined as variables that together present a complete picture of the consequences that an event has had on the environment. The empirical study was made using the tradeoff-method for one of the attributes, *the size of the affected area*.

The main conclusion that the results present is that the majority of the participants are risk seekers. To be able to draw any more general conclusions about peoples values, all the attributes would have to be studied. The correlation between them would also have to be examined.

Introduction

Research concerning how people value the loss of human lives when a disaster occurs, is conducted at *Lund University Centre for Risk Analysis and Management* (LUCRAM). Besides the loss of human lives, severe consequences on the environment can be the result of a disaster. This has been paid more and more attention over the last years.

The main goal with this work was to identify how people value the consequences that a disaster can have on the environment. A goal was also to improve the knowledge concerning how these consequences can be measured and evaluated.

The knowledge received from this work can be of great importance, both when preventive work is carried out and when a disaster already has occurred. The area that has been of concern in this work is Sweden.

Method

The work was separated into two parts; to formulate attributes and measures and to conduct an empirical investigation for one of the attributes. The first part was based on brainstorming and literature studies.

In the second part the tradeoff-method [1] was used to conduct an empirical investigation to study how people value the impact that a disaster can have on the environment. The people who conducted the survey were students attending two different educations at Lund Institute of Technology.

Part 1 – Formulating attributes

The main goal with the first part was to answer the question how environmental consequences can be measured. This was made by using attributes. Attributes are here defined as variables that together present a complete picture of the consequences that an event has had on the environment. They were formulated so that they are independent of where in Sweden the disaster has occurred or can occur. They are also independent of what type of disaster it is. To be able to quantify the consequences some kind of measurement was needed. These were also identified during the work.

A survey of possible disasters and their consequences was conducted. This made it possible to identify the values in the Swedish environment that are at risk in the event of a disaster. After this was accomplished the attributes and measurements could be formulated and placed in a tree structure, see figure 1.

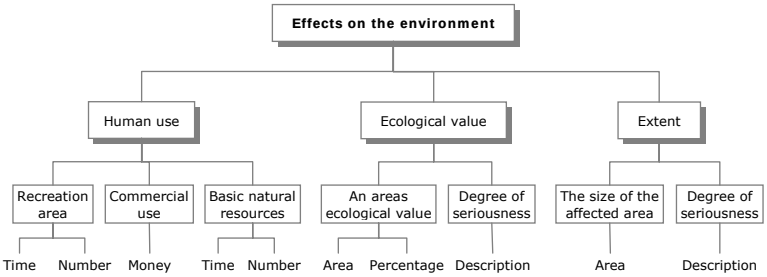


Figure 1 Tree structure illustrating different kind of environmental impact that a disaster can have. The measurements are at the end of every branch and the attributes are right above them.

The attributes were defined based on the value at risk in the Swedish environment. To secure

the quality of the attributes and measurements a number of criteria were used, with different theoretical background.

Part 2 – Empirical study

In the second part of the work, peoples values concerning the impact a disaster can have on the environment were studied. This was made empirically for one of the attributes, *the size of the affected area* with the measurement *area*. The choice of attribute was made using the earlier identified criteria. The attribute also had to give a good conception of a disaster on its own.

For the actual investigation a computerised tool was used, based on the tradeoff-method. It generates a utility function specific for every person that performs the survey. The utility function can be used to identify whether the person is risk averse, risk neutral or a risk seeker.

When a person performs the survey, values are received both from the inward and the outward procedure. The difference between these values is when in the survey they have been collected. Theoretically these series of values should be identical. Even so, a significant difference in curvature could be observed in the result from the surveys, see figure 2.

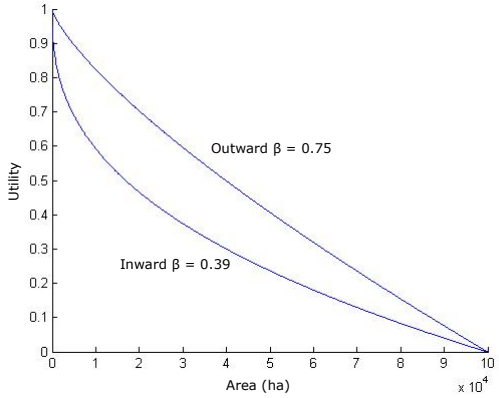


Figure 2 The mean value of the collected utility functions, with the inward and outward utility functions separated.

The same kind of difference has been observed in earlier studies [2]. It can be used as an indicator of whether or not the person who performed the test has answered consistently. Consideration was taken to this through the separation of the inward and outward values when differences between the sexes and between the two educations were investigated.

Discussion

The main conclusion that the results present is that the majority of the participants are risk seekers. No difference in risk perception between the sexes could be pointed out and no certain conclusions about differences between the two represented educations could be drawn.

The situations where the identified attributes and measurements could be of use are as a help in documentation of disasters, in prioritising different ways of action and to find out what to do when a disaster already has occurred.

The utility functions could be used to draw conclusions about what type of disaster that people experience as the most severe. They could also be used to prioritise different ways of action when a disaster occurs. To be able to do this a more extensive work would have to be done. All of the attributes would have to be investigated and the correlation between them would have to be established.

Reference

1. Wakker, Peter P. & Deneffe, Daniel (1996) Elicitating von Neumann-Morgenstern Utilities When Probabilities are Distorted or Unknown. *Management Science*, Vol. 42, No. 8, s. 1131-1150.
2. Fennema, Hein & van Assen, Marcel (1999) Measuring the Utility of Losses by Means of the Tradeoff Method. *Journal of Risk and Unceartainty* 17:3, s. 277-295.

Evaluation of airport associated aviation risks

Frida Eiman
Kajsa Jönsson

Abstract

LFV Teknik is an airport consultancy group within the Swedish Civil Aviation Administration. They make risk assessments in connection to changes of the airport routines, when new technological equipment is to be installed or when already existing equipment are to be rebuilt. The risks are assessed in a risk matrix, but today there are no standardized outlines how to perform the assessment. This results in different assessments depending on which person who made it.

Background

This thesis is a master thesis at the programme Risk Management and Safety Engineering at Lund University Faculty of Engineering. The project was carried out in cooperation with LFV Teknik with the aim to analyse common airport associated aviation risks.

The aviation industry is associated with many risks in the every day activities. On account of this all the Swedish airports must, in a form of safety cases, prove to the Swedish Civil Aviation Authority that enlarging and reconstructions that are planned to be done on buildings do not pose a risk to flight safety. Within the Swedish Civil Aviation Administration there is a particular division, LFV Teknik, that among other things works with performing safety cases. These contain a systematic survey of potential risks and analysis associated with the new system that is supposed to be introduced at the airport. After performed analysis, the risks are assessed in a risk matrix concerning the parameters probability and consequence. The axis of consequence is divided into four steps from minor to catastrophic occurrences. The axis of probability has one quantitative and one qualitative definition, and is divided into five steps from extremely improbable to frequent. Depending on where in the risk matrix the risk ends up it will be categorized into acceptable, unacceptable or to be reviewed (LFV Teknik, 2004).

LFV Teknik is dealing with a number of risks, named typical risks, which frequently recurs in the safety cases. These could for example be obstacles on or near the runway, collision between two aeroplanes, powerful braking of an aeroplane or light system failure during take-off or landing.

In the present situation there are no standardized outlines for how to perform the risk assessment. Because of this the assessments may differ from each other depending on the person who has done the assessment. People have different perception of risk that may influence assumptions and conclusions in the work of safety case. The perception of risk means that persons assess risks different because of earlier experiences, knowledge about the risk, the range of the consequences etc. The assessor also chooses how many actions in the chain of events that are to be taken into account, both with regards to possible consequences and to underlying conditions. This leads to that one and the same risk may be assessed differently from case to case, and consequently uniform assessment does not appear.

Purpose

This thesis aims to analyse the risk matrix and at forming the basis of a more objective risk assessment of 18 type risks by establish probability and possible consequences of these.

Method and delimitations

Interviews with twelve flight safety experts (pilots, safety coordinators and analysts) were made in the aim of finding possible consequences and probabilities for 18 typical risks plus belonging risks. The same questions and scenarios were used in each interview, so that the results could be put together and compared.

Risks can bring both positive and negative consequences. To increase the aviation safety it's nevertheless the negative consequences that are most important. Because of this only the negative effects has been treated in the interviews and in this thesis.

Results

The results of the interviews show that undesired occurrences, as for example disruption of light systems, which occurs before decision height do not pose a threat for flight safety. In flight simulators pilots train their ability to handle these situations and they mean that they do have time to break off approach and to do a go around. The majority of the interviewed persons also mean that the passengers wouldn't even notice that something had gone wrong during the landing and that a go around was done.

Undesired occurrences that occur after decision height do on the other hand involve increased risk. The results show that the consequences of undesired occurrences though are rare. Often the probabilities for catastrophic or major occurrences are very small. This is related to the fact that take-off and landing often are made automatically and therefore are not affected of total light failure. Nevertheless, the research also shows that the airport and the aeroplanes have got a number of safety barriers. These, for example redundant systems, make the risk often very small or non-existent. In case of a decline of more than one safety barrier at the same time, the probability is higher for serious consequences.

The most critical light system to go out is the runway centre line lights and the runway edge lights. During take-off the runway centre line lights give the pilot information about the depth of the runway and also help the pilot to keep the aeroplane centred on the runway. During landing the runway edge lights show how the aeroplane is situated in relation to the runway.

Discussion

The probabilities for the consequences were often very small, wherefore uncertainties of the results occur. For the human person it's often hard – or in some cases even impossible - to assess small probabilities (Riskkollegiet, 1991). The difference of 10^-6 and 10^-7 are one example when it's difficult to tell the difference but important to the final results. Even tough the results sometimes are spread, one can see if the risk would result in catastrophic or minor accidents and also give a hint of how probable this is.

Because of the uncertainty of the probabilities LFV Teknik is recommended to complement the results with a consensus group. The purpose of this group is to analyse the results from this thesis and to find answers from the interviews that are less reliable. An answer that sticks out among the others may depend on if the person who answered misunderstood the question, didn't have the right experience and knowledge about the risk or his/her perception of risk.

The definitions of the consequence axis in the risk matrix contain quite a lot of indistinctness. Among other things synonymous words are used in the different classes of consequences that allow free scope for the assessor to make his own interpretations. Also, only possible to assess risks associated with safety and health, despite that LFV Teknik works according to the environmental management system ISO 14001. Because of insufficient definitions the risk matrix should be completed with numbers and example of possible consequences for each class on the consequence axis. This would simplify the assessment and the differences between the assessments would be reduced.

Nevertheless this is going to be developed in the organisation of the Swedish Civil Aviation Authority and a new improved version is going to reach the organisation within two years.

Conclusions

A short summary of the conclusions of the thesis:

An undesired occurrence, which occurs before decision height, does not pose a threat for flight safety.
An undesired occurrence, which occurs after decision height, involves increased risk. The probabilities of catastrophic occurrences are nevertheless often very low.
The most critical light systems to go out is the runway centre line and edge lights.
LFV Teknik should compose a consensus group to analyse the results of this thesis because of the uncertainties of the low probabilities.

References

LFV Teknik, H., 2004, *Handbok i säkerhetsbevisning för LFV Teknik*, LFV Teknik, Norrköping.

Riskkollegiet, 1991, *Att jämföra risker*, Skrift nr 1, Riskkollegiets Skriftserie, Stockholm.

Safety Culture in Extensive Projects

Andreas Hanner
Henric Modig

ABSTRACT

Up until 2012 the Swedish nuclear power plant Ringhals AB will make extensive investments in its plant. During the projects following these investments it is of great importance to create a good safety culture. Field studies have been performed with the purpose to find strategies for creating a good safety culture during project activities. The field studies consisted of interviews with 13 individuals involved in projects within Ringhals AB as well as in external and extensive projects. The results stated in the report cover all project phases comprising initiating, planning, executing, monitoring and controlling, and closing phases. Throughout the report quality and safety has been regarded as inextricably linked.

INTRODUCTION

Since the middle of the 1990s some extensive projects performed at the nuclear power plants Ringhals and Barsebäck have not held the quality hoped-for which have led to delays and extra costs. Internal investigations have been performed resulting in some suggestions to improve the project organization. Up until 2012 Ringhals AB will perform extensive changes to the industrial site. Thus, several projects will take place during this period of time and this will involve the use of many contractors. During the projects it is of great importance to create a good safety culture, which eventually also will contribute to a successful result.

Ringhals AB is a part of the Ringhals Group which is owned by Vattenfall (74,2 %) and E.ON (25,8 %) [1]. The nuclear power plant Ringhals is located 20 kilometers north of Varberg on the coast. Ringhals has four nuclear reactors, R1-R4, of which R1 is a boling water reactor while R2-R4 are pressure water reactors. Every summer Ringhals shut down the reactors to replace worn out fuel and to do maintenance work on the equipment.

The aim of the Master's thesis has been to find fundamental factors and strategies that contribute to a good safety culture during extensive projects.

THEORY

We have studied different literature about safety culture by authors like Reason, Roughton and Mercurio, Weick and Sutcliffe, and International Nuclear Safety Advisory Group (INSAG). Safety culture is not a concept with a single definition. However, some characteristics like management's commitment to safety, attitudes towards safety and a learning organization must be included. A simple way to describe culture is *"it is the way we do things around here"* [2]. Weick and Sutcliffe [3] uses the term High Reliability Organizations, HROs, for organizations operating under complex circumstances but nevertheless have a relatively low rate of accidents. Some nuclear power plants, air traffic controls and nuclear aircraft carriers are represented in this category. The relatively low accident rate can partly be explained by the term *mindfulness* [3] which includes inter alia preoccupation with failure and commitment to resilience.
We have also studied pertinent literature regarding interview techniques and how to construct interview questions.

METHOD

We performed 13 interviews of which seven were with Ringhals personnel involved in the internal project organization. Five interviews were performed with representatives of extensive projects with an overall active safety component, and one interview with a researcher representing the National Institute for Working Life. The external projects we have chosen to study are Götaleden, Södra Länken, Högakustenbron, Citytunnelprojektet and Gasoljeprojektet at Preemraff Lysekil.

When we created the interview questions we tried to avoid yes/no-questions and delicate questions. If a delicate question had to be used we tried to tone it down with a well chosen opening phrase [4].

Our first interview was with the researcher from the National Institute for Working Life.

A week before the interview we sent the questions to the interview person in order to provide a possibility for preparation of the answers. In spite of this measure the interview material was too extensive and after the interview we also understood that the questions were too leading and did not give the interview person a possibility to speak freely about the subject. Therefore we rewrote the questions and made them less leading and less extensive.

During the interviews we both recorded and took notes. Afterwards we listened to the interviews and wrote down what was said but not word-for-word. After that we summarized the texts and made them more readable before we sent the texts to the interview persons for their approval. By doing this we minimized the possibility for misinterpretations.

RESULTS

The results consist of one general part that should be present throughout the whole project life cycle and one part directed to each single phase in the project life cycle. The partition of a project into different project phases is based on A Guide to the Project Management Body of Knowledge [5]. The phases are Initiating, Planning, Executing, Monitoring and controlling, and Closing (IPEMC). The following results are just a selection of the complete results stated in the main report.

General results-Risk management

The top management's commitment is essential for the risk management in a project organization, just as in every organization. Without the top management's support the risk management process will be unsuccessful. Furthermore, it is important for a project organization to create a database of risks. Such a database is useful for documentation and evaluation of the project's risks, and it is convenient to connect the database to the timetable. Regarding risk management it is also important that the person responsible for an activity also is responsible for managing the risks connected to it

General results

The quality of the project will be enhanced if the contractors that are hired are given a chance to make a profit.
It is important to constantly keep the safety message present, especially at the end of a project when it is quite easy to relax and accidents will happen as a consequence of this.
The project management must be committed to and have an interest in the work of all project team members. However, this commitment and interest must not appear through activities of a police character. The project management also have to be visible in the project organization and serve as a role model for the personnel.
A sustainable reporting culture has to be based on a no blame concept, although the difference between acceptable and unacceptable behavior has to be well-known by all staff. If a project affects a line organization it has to be in the line organization's interest to receive reports on incidents and near misses.

Results according to IPEMC

Initiating

The orderer of a project must have a commitment to safety from the initial phase of a project. In order to achieve good conditions, clear requirements of safety and working environment have to be included already when the orderer request offers and bids from sellers and contractors.

Planning

In the beginning of the planning phase the project manager should gather the

management team to discuss all possibilities and challenges of the project. It is convenient to arrange such a gathering in a private and social environment since it is beneficial to the cooperation and communication between the management team members.

Executing

During the executing phase of a project it is important to support external resources such as contractors. Contractors possess a lot of expertise but they sometimes need help to make use of this expertise if the project environment is complex.
Campaigns with alternating focuses are useful tools in projects with long-term executing phases. A campaign with an alternating focus works as a forum for the most important activity at a specific occasion.

Monitoring and controlling

Internal audits are useful to control the work of the project management team. Internal audits should be carried out by persons who have certain knowledge about the project, although they should not be fully involved.

Closing

After a project has been finished it is of great importance to learn from the project. This includes positive experiences as well as negative ones. A concluding workshop is probably a better way to learn from the project than a written and extensive final report.

DISCUSSION

The following notes discuss the usefulness of the report and its results. Literature about safety culture is mainly directed to line organizations, not dynamic and temporary projects with a high staff turnover. Thus, it is difficult to connect the practical results to the theory about safety culture. Furthermore, we think that safety culture as a term is not fully well-known in all line of businesses and therefore the idea of the safety culture concept and its expressions might have differed between us and the interview persons. There is a possibility that we and the interview persons have talked about the same things in different words, and vice versa.

REFERENCES:

[1] Ringhals, 2005. *Vår verksamhet » Om Ringhals.* [Online] Available at: http://www.ringhals.se/index.asp?ItemID=1290, 2005-11-18.

[2] INSAG 15, 2002. *Key Practical Issues in Strengthening Safety Culture INSAG Series No. 15,* International Nuclear Safety Advisory Group, IAEA, Wien, Österrike, ISBN 92-0-112202-0.

[3] Weick, K.E., Sutcliffe, K.M., 2001. *Managing the Unexpected: Assuring High Performance in an Age of Complexity,* University of Michigan Business School management series, Jossey-Bass, San Fransisco, CA, USA, ISBN 0-7879-5627-9.

[4] Langlet, P., Wärneryd. B., 1985. *Att fråga - Om frågekonstruktion vid intervju- och enkätundersökningar,* Statistiska Centralbyrån, Stockholm, ISBN 91-38-05283-0.

[5] Duncan, W.R., 1996. A Guide to the Project Management Body of Knowledge, Project Management Institute, Upper Darby, USA, ISBN 1-880410-12-5.

Risk- and vulnerability analyses as a basis for municipal planning for managing extraordinary events

Karl Harrysson
Joakim Malmsten.

Abstract

The Swedish system for crisis management is changing. Among other things, this has resulted in the law (2002:833) concerning extraordinary events in times of peace in municipalities and county councils, which states that municipalities must produce a plan for managing extraordinary events. In this study, a hypothesis concerning how the plan can be based on risk- and vulnerability analyses is developed. The process described in the hypothesis is compared to the current work in three studied municipalities. We also discuss coordination of the planning process with production of programmes of action for civil protection according to the Civil protection act (2003:778).

Introduction

Planning and preparation for crises in Sweden have previously been focusing on everyday accidents and situations of war. In order to include serious events in times of peace, the *law* (2002:833) *concerning extraordinary events in times of peace in municipalities and county councils*, was made (authors' translation). An extraordinary event is defined as "*an event that deviates from the normal situation, implies a serious disruption or imminent risk for a serious disruption in vital societal functions and requires prompt actions by a municipality or county council*". The law requires several actions in order to improve the municipal handling capability. Municipalities must produce a plan for managing extraordinary events. The law also offers an opportunity to manage crises in a faster and more efficient way by establishing a crisis management committee, which has a mandate to overtake decision making from other municipal committees.

Currently, there are no detailed recommendations as to how municipalities are supposed to develop the plan concerning extraordinary events. The law's preparatory work, however, states that risk- and vulnerability analysis of all municipal activities should be used as a basis for the planning process (SOU 2001:105). This recommendation is extended in a recent agreement between the government and the Swedish Association of Local Authorities (Försvarsdepartementet, 2004). In the agreement, it is stated that risk- and vulnerability analysis *shall* be used as a basis for the planning process.

Method

Research regarding the use of risk- and vulnerability analyses in all phases of a crisis is being conducted within *FRIVA* 's (Framework programme for Risk and Vulnerability Analysis) Subproject 3 (Abrahamsson et al, 2003). *FRIVA* is a framework research programme, funded by the Swedish Emergency Management Agency, which is being conducted by *LUCRAM* (Lund University Centre for Risk Analysis and Management). The work discussed in this paper is a preliminary study within Subproject 3, with the ambition to develop ideas within the subproject and to apply these to the municipal planning concerning extraordinary events. In order to do this, a hypothesis to describe how municipal planning could be conducted has been developed. Thereafter, a comparison between the hypothesis and the current work within three municipalities (Malmö, Lund and Svedala) is made.

Developed hypothesis

The developed hypothesis (see figure below) is based on risk- and vulnerability analyses. The results from the analyses will be presented as a list of events, for which probabilities and consequences are estimated. The consequences are a combination of all negative effects an event gives rise to. The identified events are presented in an *event matrix*. Depending on an event's position in the matrix, an assessment of if and how each event should be managed in order to improve the safety within the municipality.

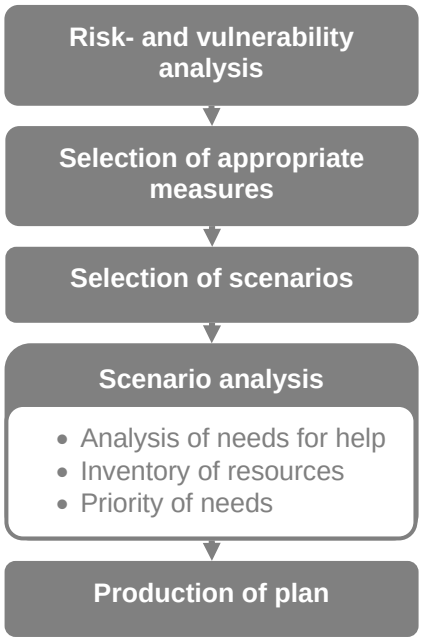


Figure. Hypothesis

The events in the most serious class of consequences in the matrix are comparable to extraordinary events. Well-conducted risk- and vulnerability analyses will be likely to identify several such events. In order to be able to conduct a deeper analysis of how these should be managed, it is therefore necessary to make a representative selection of suitable events. This selection should be done in a way that gives a good variation in the needs for help and the measures that are going to be relevant in each case. After the selection, an analysis is performed of the selected scenarios. We believe that 5 – 10 scenarios yield a reasonable workload for the municipalities and are adequate to cover a relatively broad spectrum of possible events. In the scenario analysis, a thorough assessment of possible needs for help and the resources required to respond to these is conducted.

A plan which takes the important aspects from the analysis into account should then be written. The plan should be designed as a concrete support in a crisis situation. Therefore, it must not be too extensive or contain unnecessary information. It is also important, however, that it is not so slimmed that important information is left out. How much information the plan should contain and how it is designed are complex issues (Perry, 2004) and are not discussed in detail in this paper. Instead, we believe that these questions should be decided by each municipality in order to promote an adjustment to local conditions.

Since the advantages of coordinating the planning for extraordinary events and the production of programmes of action for civil protection according to the *Civil protection act* (2003:778) is discussed in several documents (see eg SOU 2001:105; Försvardepartementet, 2004), we believe it necessary to discuss how this could be done. The coordination is based on the idea that the same risk- and vulnerability analyses should be used as a basis for total municipal risk- and crisis management. Information from the *selection of appropriate measures* can be used when producing the programme of action for preventive work. It is also appropriate to use information from the *selection of appropriate measures* when producing the programme of action for rescue services. In this case a scenario methodology, similar to that in the main hypothesis, is used.

Since there has been no time for implementing the hypothesis in a municipality, the thoughts regarding the applicability is purely theoretical. The conclusions drawn from our studies are as follows:

- The municipal planning process must be changed
- There are no guidelines for the planning process
- The suggested method would make the planning more systematic
- Coordination of the planning is improved
- The municipalities have different opinions regarding the plan's design

References:

Abrahamsson et al, 2003. Ansökan om medel till ramforskningsprogram inom området "Risk och sårbarhetsanalyser"

Försvarsdepartementet, 2004. *Kommunernas uppgifter i samhällets krishanteringssystem.* Dnr Fö2003/2001/CIV, no 10

SFS 2002:833. Lagen om extraordinära händelser i fredstid hos kommuner och landsting

SFS 2003:778. Civil protection act

SOU 2001:105. Extraordinära händelser i kommuner och landsting

Perry, 2004. *Disaster exercise outcomes for professional emergency personnel and citizen volunteers.* Journal of contingencies and crisis management, vol. 12 no 2, pp 64-75

Evaluation of the risk of contamination - A proposal for how to evaluate the risk of contamination as a result of emission from a road construction

Karin Holmkvist

Abstract

To find the most suitable solution for a road planning several aspects has to be taken into consideration. Some of these are the design of the road, the impact of the construction on the surrounding environment and the technical properties of the materials used in the construction. Another important aspect is the risk of contamination as a result of emission from the materials used in the road construction. This study proposes a method on how to evaluate risk of contamination as a result of emission from materials used in road constructions.

Introduction

Natural materials are the most commonly used materials in a road construction. The use of natural materials has led to a decrease in the supply of e.g. natural gravel in some regions in Sweden [1]. This has caused a search for new alternative materials. Secondary materials from e.g. iron production and waste combustion have shown good technical properties that make them suitable for road constructions. Some of the materials contain substances that only occur in small amounts in the environment. These materials can therefore be a source of pollution. To determine whether a material can be used for a road construction the risk of contamination to surrounding environment has to be evaluated.

The aim of the study is to present a proposal for how to evaluate the risk of contamination as a result of emission from materials used in a road construction. The study will also illustrate how experts in governmental agencies, industries and universities evaluate the risk of contamination.

Method

The study is based on literature studies, an inventory and a questionnaire.

The purpose with the inventory is to examine risk criteria and if the terms 'minor risk' and 'significant risk' of contamination are used at evaluation of risk. These terms are studied since they are used in the part of the Ordinance (1998:899) concerning Environmentally Hazardous Activities and The Protection of Public Health regarding waste materials [2]. The inventory is based on documents about secondary materials collected from material producers and governmental agencies.

The purpose with the questionnaire is to examine how experts in governmental agencies, industries and universities evaluate the risk of contamination. The questionnaire seeks answers to the following questions:

- Do experts that have the same information evaluate the risk of contamination equal?
- Do experts with the same profession evaluate the risk of contamination equal?
- Which aspects influence an expert's evaluation?

The questionnaire consists of four scenarios. Each scenario is presented with a figure of the diffusion of one or more substances with the ground water. The concentration of the substances on three distances from the construction is also presented. In the first three scenarios chloride, zinc and cadmium ions are emitted from the construction, respectively. In the fourth scenario all three types of ions are emitted. Each scenario consists of two examples; the first with a source of water supply 50

meters from the road construction and the second without a water supply. The task is to evaluate whether the risk of contaminating the groundwater is insignificant, minor or significant. The term insignificant is used as a complement to the other two terms described in Ordinance (1998:899).

Results

The inventory indicates that guidelines for evaluating the risk of emission from secondary materials in a road construction do not exist. The criteria used today, are for example the Swedish National Food Administrations criteria for drinking-water and the Swedish National Environmental Protection Agency criteria for contaminated sites. The result of the inventory shows that the risk critera used are worked out for other purposes, as previously described by Visser [3]. The inventory indicates that the terms 'minor' and 'significant' are only used in a few of the documents.

The result of the questionnaire indicates that the object to protect changes when there is a source of water supply close to the road. If there is a risk for humans to come in contact with the water the risk of contaminating emission from the road construction is evaluated as a 'significant risk'. Suggesting that the endpoint, i.e. groundwater, has changed to humans, figure 1. Further, the questionnaire indicates that experts at governmental agencies, industries and universities evaluate the risk of pollution differently and they seem to take other factors than the risk of contamination and the endpoint into account at their evaluation. The conclusions of the questionnaire are: that there is no common way to evaluate the risk of contamination as a result of emission from materials in the road construction, there is no uniform interpretation of the terms 'minor' and 'significant' risk of contamination and that the evaluation is
subjective.

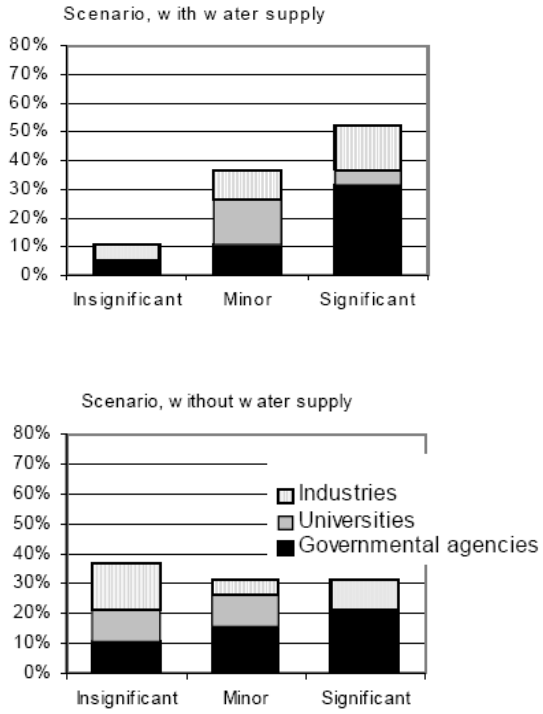


Figure 1. The graphs present the result from the scenario where chloride, zinc and cadmium are emitted from the road construction. In the first graph there is a source of water supply nearby and in the second graph there is no source of water supply.

Conclusion

A proposal for how to evaluate the risk of contamination from materials in a road construction based on the literature studies, the inventory and the questionnaire.

- Identify the endpoint to protect. To whom or what in the system should the risk of contamination be acceptable? The selection can be based on five principles; an unambiguous definition, the effect on the endpoint should be measurable and the effect should be susceptible to the exposure of substances. The endpoint should have both social and biological relevance, which means that humans should value it and that it should have an important role in the ecological system [4]. These principles will not point towards an endpoint but they may decrease the number of objects to chose from.

- Estimate the magnitude of risk of contamination for the chosen endpoint and use this as the starting point for the evaluation. Base the estimations on the probability of emission and its negative effects on the endpoint.

- Set the risk of contamination in relation to the benefits of the system. A risk evaluation should not only be based on the magnitude of risk but also in regard to the benefits with the system [5]. The benefits can be environmental, economic, technical etc. When a secondary material is selected in favour of a natural material the benefits are a decreased use of natural resources and a use of secondary materials that otherwise would have been deposited. Other benefits could be a simplified or a more durable construction.

- What is the acceptable risk of contamination? Suggestively, the answers can be divided into four different levels that are connected to criteria for control or reduction of the risk. The levels can also be connected to the part of the Ordinance (1998:899) concerning Environmentally Hazardous Activities and The Protection of Public Health that consider waste materials, table 1.

Table 1. Graduation of the risk of contamination.

Level	Magnitude of risk	Risk reduction/-control	Level of authority
Yes	Insignificant	-	-
Yes	Minor	Documentation	Notification to municipal board
Yes	Significant	Control program	Application to county administrative board
No	Not acceptable	Change in the system	-

To make future evaluation processes easier and more uniform a model of how to estimate the magnitude of risk of contamination needs to be established. Suggestively, risk criteria for certain valuable endpoints have to be designed.

References

[1] Vägverket (2000). *Användning av restprodukter i Vägbyggnad*. Publikation 1999:161.

[2] Ordinance (1998:899) concerning Environmentally Hazardous Activities and The Protection of Public Health. Latest version: 2002:557. Hämtad 2005-01-28. Tillgänglig: < http://www.internat.naturvardsverket.se/documents/legal/hazard/ordinanc.pdf >

[3] Visser M. (2003). *Bedömningsunderlag för användning av restprodukter i vägbyggnad : med fördjupning inom aspekten ekologi*. Examensarbete 2003:127 CIV. Luleå: Luleå Tekniska Universitet

[4] Suter G. W. & Barnthouse L. W. (1993). *Ecological Risk Assessment*. Boca Raton: Lewis Publisher

[5] Riskkollegiet (1991). *Att jämföra risker : information och rekommendationer från Riskkollegiet*. Skrift nr 1. Stockholm

How may experience from accident investigations be of benefit to society on a local level – on the basis of an MTO-R (Men, technology, organisation and risk management) perspective

Carl Håkansson
Dan Svensson

Abstract

The theme in this report has been how to benefit experience from accident investigations. The demand on the municipality to perform accident investigations is relatively new, and maybe they aren't clear what the demands means. This causes that there might be a problem to benefit experience from accident investigations, for improving the overall safety in the municipality. The main purpose of this report has been to clarify how experience from accident investigations, can be of benefit to society on a local level. This is done on the basis of a study of the municipality. A further purpose has been to illustrate for the reader, witch basic conditions that are needed to create a learning organisation and further on a safety culture. The last purpose has been to explain how to improve the work with benefiting the experience, when the basic conditions exist.

Introduction

On account of accident prevention legislation took effect in January 2004 is it nowadays a duty for the municipality to investigate accidents. This shall be done in a reasonable extent and should give answers to questions like – witch was the causes of the accident, what were the course of events, how the rescue service acted. The report also discusses accidents that don't cause the need of a rescue service. The intention is that the municipality shall be able to extract experience from every accident or incident and later on use this experience to improve the overall safety in the municipality and a union. The experience can also be used in an even bigger perspective, namely to achieve an improvement of the overall safety work in the society.

The main purpose in this report has been to clarify how experience from accident investigations, can be of benefit to society on a local level – on the basis of an MTO-R perspective. The intention has also been to compare if there is a difference in this work depending on the size of the municipality or the numbers of municipalities in a union. The report will also illustrate the basic conditions that are needed to make use of the experience from accident investigations in an effective way. In the end of the report we will give an example of a work procedure that hopefully will facilitate for the municipalities and the unions in their work with experience from accident investigations.

Method

The methodology that we used to produce the report has been to first decide what objective the report should have. The next step was to formulate a discussion witch consider different problems today in the matter of benefiting experience from accident investigations. Which things work well, what problems in this work exists today and what could be done to improve this work. Those were some questions that we asked each other. This discussion took place in the beginning of the making of the report and was conducted in association with the instructor. After that we had a discussion with our assigner NCO, National Centre for Learning from Accident (witch is a part of the Swedish Rescue Services Agency) , to be able to prepare the final presentation of the problem.

In the feasibility study we studied different scientific methods to finally be able to choose a method for our study. This was done because we wanted the method to reproduce a description of how the municipalities and the unions could handle the situation with experience from accident investigations that is as true as possible. For the main study, we choose the method that describes the situation in a subjective and a qualitative way. The study itself is completely empirical. For us to be able to assess and survey how the work with experience from accident investigations and MTO-R is carried out in the municipalities and the unions, we choose to implement a questionnaire. The questionnaire includes 15

questions witch are formulated so the respondent are able to answer free as they like. The first 10 questions refer to survey how far the municipalities and the unions have reached in their work with experience from accident investigations. The last five questions have the aim to survey how far the municipalities with their administrations have reached in their work with MTO-R.

An analysis over the numbers of the arrived answers has also been made in the report. This is done to get an opinion of how reliable the results are. Due to the low answer frequency in the study, it hasn't been possible to compare the different municipality groups or unions. It's not either possible to give a definite description of the situations of how the work with experience from accident investigations is carried out today in Sweden's municipalities. However it's possible to get a wide foreseeable description of the situation of how the work with experience from accident investigations is carried out today by them who answered. Its possible to also get a comprehensive description of the situation of different problems, thoughts and ideas from the answers witch affects the work with experience from accident investigations.

Results with discussion

The most important results from the study that we carried out were those that today the respondents have reached furthest in their work with developing routines for accident investigations and reports of incidents and deviations. In general, most of the respondents in the different municipality groups or unions today have set up routines to implement an accident investigation.

In the matter of routines for experience from accident investigations only a few of the respondents have indicated that they today have started up the work with developing routines for this. The reason why this work not has come any longer is considered to depend on that the respondents until now, has concentrated their work to developing routines for accident investigations, witch of course is excellent and a natural first step. We consider that it is important not to rush to fast in this work. Its better that you try out an affective way to work with accident investigations before you take a step further to develop usefully routines for the work with experience from accident investigations.

Almost all respondents in the study has answered that the experience from accidents could be very useful and the experience could take part to implement, partly to directly measures and partly serve as the basis for long-term measures. A recurring answer is however that often there is a lack of time and resources to carry on this work. The respondents also mentioned that there is an ambition and will to learn of experience from accident investigations. However there are some differences in these ambitions between the different administrations in a municipality, or between municipalities that are members in the union. We concerned that the differences in the will to learn from experience, depends mostly on the different traditions and attitude to safety in the work with safety in the different administrations in a municipality, or in the different municipality's that are members in the union.

The respondents in the study has expressed that there, in general, is a limited knowledge about the concept of MTO-R. They also expressed that today there is none active MTO-R work in the municipality's or unions. However the answers tell us that there is an ambition and willingness to be better in this work. Accordingly to the study it shows that there is some insight about the MTO-R concept. We concerned that the respondent's can not see the connection between the detailed parts. Because of this we think there is a risk to miss the overall picture.
Our opinion with the overall picture is that you shall not only look at the direct causes, but also understand the behind and overall causes of the accident. The purpose with this is to get as valuable experience as possible, because the municipalities with their often scarce resources will provide the economic resource where they create the most use. This to prevent that similar accident not occurs again, or to relief the consequences of a similar accidents.

To sum up we concerned that if the municipalities and unions shall be able to improve the overall safety it demands that they strives to be a learning organization. This means that there has to be a willingness and ambition to learn about safety thru the experience from accidents investigations, and that those experiences shall be of benefit in the best possible way.

With be of benefit we mean that the experience from accidents investigations shall

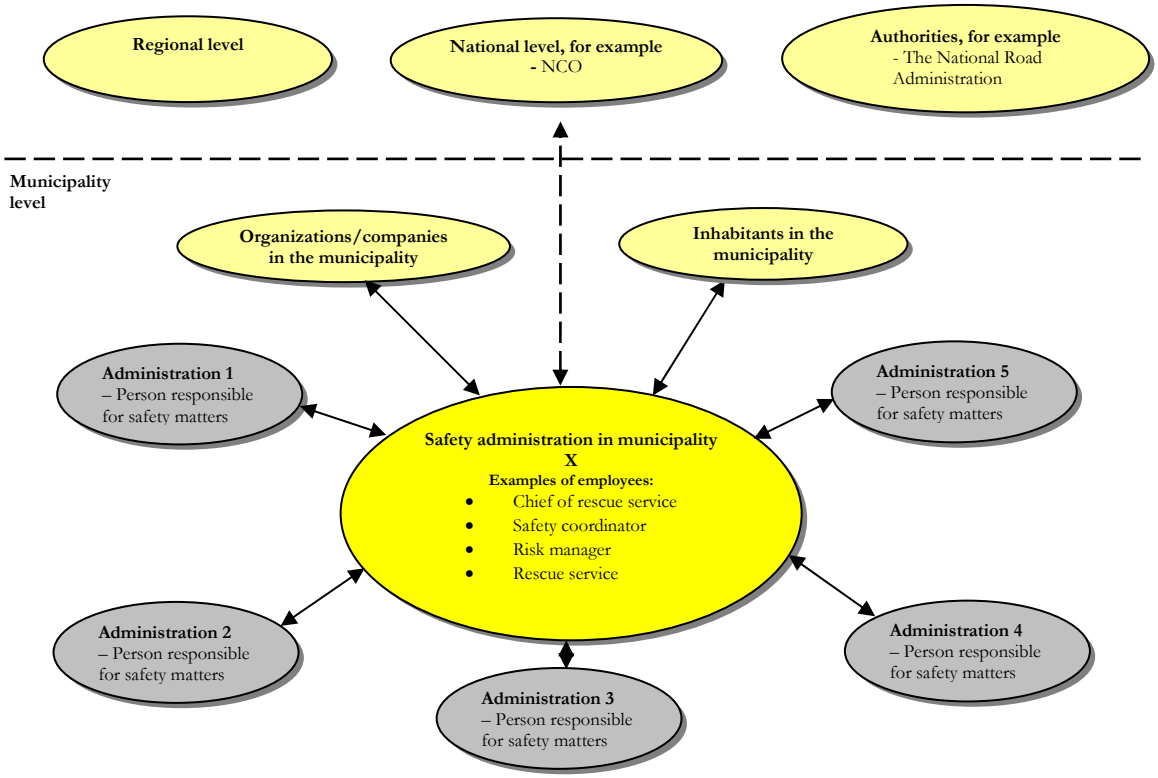
give the possibility to result in a change to suggest to improve the municipalities overall safety. This can result in that the safety increases for example municipalities, different administrations, company and organizations in the municipalities. And the most important off all that the inhabitants of the municipalities feel that they live in a safe and secure municipality.

Conclusions

The conclusions of the report have been, that today, very few of the respondents have legible routines how to benefit experience from accident investigations, and very few of them have knowledge about the MTO-R concept.

General discussion

That the municipality have the ambition to develop a learning organisation is one basic condition to later on be able to achieve a good safety culture. If a municipality or a union shall be able to develop a learning organisation and a safety culture, we mean that there has to be a coordinating function witch has the time and the involvement to handle safety matters. For example an administration called the safety administration.



The main reasons to develop a safety administration are, according to us, that it should lead to more time and resources for the work with experience from accident investigations and the overall safety in the municipality. The safety administration should also have the ambition to develop common routines for all the administrations in the municipality for them to make use of experience from accident investigation. A further task for the safety administration could be to achieve that the municipality and the union to develop a learning organisation and further on a good safety culture.

To get a good communication between the administrations in the municipality, one of the first tasks for the safety administration should be to create a network between all the administrations in the municipality. This network aims to create a channel for the safety administration to reach out and spread information and experience from accidents to every other administration in the municipality. But it should also be a channel for the administrations to get in contact with the safety administration.

A union consists of a number of municipalities. This means that there in each municipality in the union will be a safety

administration. We have the opinion that also in a union there should be a network that aims to create a channel for reaching out and spreading information and experience from accidents.

The reason that we suggest the municipalities to create a network were the safety administration has a coordinating role, is that there should exist a good communication in the municipality and in the union. The network gives the municipality and the union the opportunity to benefit experience from accidents and be able to upgrade the safety directives.

At last we want to emphasize that there has to exist a great involvement from the municipality management in safety matters. Otherwise the process with benefiting experience from accidents will stop when the real enthusiast or the most energetic person disappears from the organisation (Inspiration from Akselsson, 2004)

Reference

Akselsson, R. (2004). Course compendium in the course *Människa, teknik, organisation och hantering av risker* (2004). Dept. of Design Sciences, Division of Ergonomics and
Aerosol Technology, Lund Institute of Technology.

Audit systems – values and suitable audit users

Emma Järund
Sara Radu

Abstract

This report aims to identify and categorize suitable audit users and furthermore establish which values these users experience. The aim of the report has been fulfilled by analyzing interviews carried out with several companies using audits as a part of their risk management process. In addition to this, theories concerning management have been studied.

Introduction

Audits have been used in different shapings and in different areas for a long time. The suppliers of auditsystems have, through experience gained by cooperating with customers for several years, gotten a sense of which customers are suitable users of audits systems. Likewise they have an idea of what values these users experience. Aon Sweden AB is one of the above mentioned suppliers. Since they haven't carried out any study regarding suitable audit users and values connected to audits so far the objectives of this report is to establish which the suitable audit users are and what values they experience.

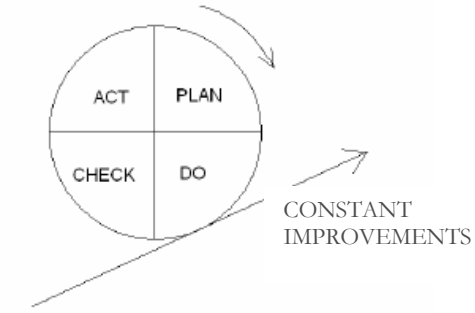
Method

In order to fulfil the objectives interviews with several audit users have been carried out. The audit users represent the following companies: Alfa Laval AB, Eka Chemicals, Gambro, Höganäs AB, Mölnlycke Health Care, Scania, SSAB Tunnplåt, Swedish Match, Sydkraft och Trelleborg. Parallel to the empirical work theories have been studied. Besides this founders and suppliers of auditsystems have been intervjued in order to gain knowledge concerning the systems. The systems studied in this report are: FRiME from Aon, Aon Auditor, Willis Blue, Pandora from Zurich, which are regarded as external auditsystems since they are supplied as an external service. Furthermore two internal audit systems, SW.IRMA and SHE-audit from Kemikontoret, have been studied. These are handled completely within the company or enterprise.

The report focuses on general approaches to risks and management, which can form a base for a healthy risk management culture and thereby facilitate work with audit systems.

Theory

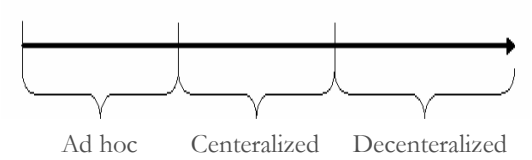
There are several theories that not only support working with audit systems but also have contributed to the result of this report. One central theory is *Double Loop Learning*, which means that new information gained in one division of the company is gathered up and evaluated by a central function in the company. Vital information can then be spread to all divisions throughout the entire company. Another theory that has been of use to this report is *Demings circle*, also known as *the PDCA circle*.



Demings circle illustrates a way to achieve constant improvements by planning, doing, checking and acting. The key to this way of work is to not stop after act but instead start again from plan and see this way of work as a continuous process that never ends.[1]

Results

Concerning external audit systems the authors have, based on the interviews, come to the conclusion that companies interested in recieving an external examination and a uniform assessment for the entire enterprise are suitable audit users. For companies interested in a uniform assessment internal systems can also be suitable. However they do not provide an independent examination. A categorization of the suitable audit users has been done based on the developement of the organizational risk management work from unstructured risk management in the *ad hoc phase* through the *centeralized phase* with central coordination to a *decenteralized phase* where risk management has become a natural part of everyday work.



The aim of audit systems, external as well as internal, is mainly to enable benchmarking. What values audit systems generate, apart from this, mainly depends on what working procedures the company chooses. The following values should be seen as a compilation of all identified values and are not valid for all companies.

Actual values:

- Benchmarking, internal as well as external, is enabled
- New risk areas can be identified with strengthened safety as a possible consequence
- A better starting point for negotiations with insurance providers can result in decreased insurance premiums
- Opportunities to get new assignments and customers are created as the company qualifies to participate in negotiations and purchases

Values experienced by the companies:

- Accomplished improvements can be seen
- The structure of the risk management work improves
- The risks become more clear
- That the risk management is handled in compliance with policies is confirmed and creates confidence
- Credibility is created through external examination
- Image, internal as well as external, is enhanced
- A risk management policy can be created or, if one already exists, gain more focus
- A motive force for systematical improvement is gained
- The risk awareness among employees is enhanced
- Motivation to excecute improvements is gained by receiving the immediate feedback that internet based audit systems provide
- Responsibility is delegated destinctly
- Level for decisionmaking is clarified

Future values according to the companies wishes:

- Improved external and work environment as a consequence of including these areas in the systems
- A connection between the cost and effect of an improvement

Values experienced by the authors:

- Possibilities for constant improvements and learning through a central gathering of both experienced weakenesses and strengths are created
- A channel for incident reporting is created
- Comparison of incidents is and accidents is facilitated and accidents can thereby be avoided
- Through benchmarking lessons from already occured near-accidents can more easily be learned

References

[1] Akselsson, Roland (2004) *Människa, teknik, organisation och riskhantering.* Institutionen för Designvetenskaper, Lunds tekniska högskola, Lund.

Municipal management of environmental risks associated with accidents

Nan Kjellberg
Cecilia Sandström

Abstract

This article is an executive summary of a Master Thesis in Risk Management and Safety Engineering. The purpose of the project has been to investigate how environmental risks should be incorporated into the municipal management of accidents in Sweden, and to evaluate the potential use of the program Riskera in the municipal management of environmental risks associated with accidents. Riskera is a tool based on Geographic Information System (GIS), which has been developed by the Swedish Rescue Services Agency (SRSA).

Literature studies, interviews and observations have resulted in a number of recommendations, instructions and key factors regarding how to incorporate environmental risks into the municipal management of accidents. One very important factor is a learning organisation.

Introduction

Accidents with consequences for different parts of society occur on a daily basis in Sweden. These consequences can affect different values and according to the *Civil Protection Act* (2003:778), which was implemented on the 1st of January 2004, society has to prevent and minimise damage on people, property and the environment. Traditionally, environmental damage has not been given much attention. This is now changing as accidents have shown to have potentially very large environmental consequences, which cannot be neglected. Pollution of the environment also has great impact on human health.
To enable a decrease in the number of accidents that occur, as well as preparing to cope with the consequences of the accidents, society has to work systematically with risk management and civil protection. Accidental risks have to be identified, analysed and evaluated, and actions, contributing to improvement of society's protection against accidents, have to be taken. Civil protection also includes effective management of accidents that do occur in spite of preventive actions, see figure 1.

Environmental risks have to be incorporated into both accident risk management and civil protection in the municipalities. Management of accidents is in Sweden mainly performed at local level, which makes the municipality an important actor in this process. Moreover, the municipalities often have to deal with the consequences of accidents, and hence have strong incentives to work with these issues.

SRSA has developed a tool, in order to facilitate the daily risk management work of the Swedish municipalities. The program is called Riskera and is based on Geographic Information System (GIS). At present the program is only used by a limited number of municipalities, but the intention of the SRSA is to spread it to a considerably larger number of users.

The purpose of this project has been twofold: to *investigate how environmental risks should be incorporated into the municipal management of accidents*, and to *evaluate the potential use of the GIS-based program Riskera, developed by the SRSA, in this work*. Theory, legislation, actors and aids/tools of relevance for the purpose of the project have been studied in literature, and through interviews and observations. In addition to these studies, information has also been acquired concerning Canada's work with environmental emergencies, in order to add another perspective to the analysis.

Results

The project has resulted in a number of recommendations and instructions regarding how to incorporate environmental risks into the municipal accident management. These have been structured on the basis of a methodology combining *risk management* with *civil protection*, see figure 1.

It is also suggested which actor should be responsible for carrying out these recommend-dations and instructions. The majority of these actors are municipal ones, but also some national authorities are referred to. This structured advice

is intended to support and inspire the important actors, such as the Municipal Environmental Agency and the Municipal Rescue Agency, in their daily activities.

Such recommendations are for example to perform first response exercises with more actors than solely the Municipal Rescue Agency and to involve the Municipal Environmental Agency in the process of auditing corporations' risk analyses in situations concerning for example their establishment, in order to ensure a sufficient coverage of environmental risks. More recommendations are presented in the report.

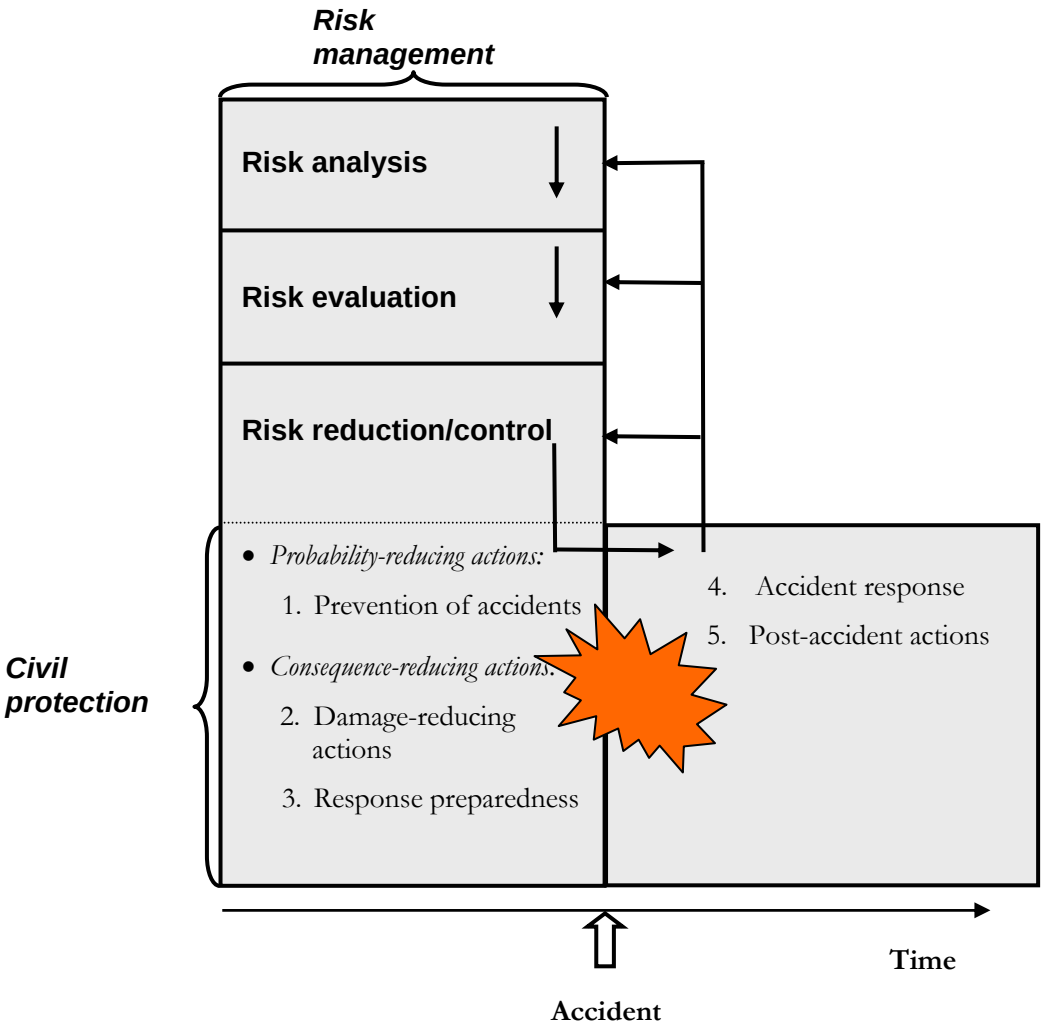


Figure 1, Methodology for management of accidents combining risk management (vertically) and civil protection (horizontally).

Key factors

Apart from specific recommendations and instructions some key factors have been identified as being vital for acquiring good municipal management of environmental risks associated with accidents.

A learning organisation

A good municipal organisational learning is a very important factor to assure an adequate safeguard of knowledge and experiences in the municipality. Knowledge about many different aspects is required to integrate environmental risks into the municipal management of accidents. Without safeguarding the knowledge within the municipality, the result of the risk management process is at best inefficient, and at worst hazardous.

An efficient organisation of the municipal management of accidents

Hand in hand with improving the municipal organisational learning with respect to accident management goes an efficient organisation of the actors involved. Societal risks are complex and reliable management of these requires the participation of a large number of actors. A risk management function at a municipal management level, such as a safety coordinator or a safety group, is of great significance for all these aspects. This is also of vital importance for assuring that all the important aspects of accident management in the municipality are taken into account.

Awareness and knowledge among involved actors

Another important factor is the awareness and knowledge among the actors. For example educating and training commanders in charge of the first response on environmental issues is of vital importance. Educating and training personnel at the Municipal Environmental Agency on management of accidents is also very important.
Different basic data for decision-making, such as programs, tools and databases, must be used at several occasions when the decision-maker's knowledge is insufficient.

Riskera as a tool in the municipal management of environmental risks associated with accidents

The program Riskera is an example of a tool that can be used by decision-makers to acquire additional information before making a decision, mainly in risk management on a municipal management level. It is mainly a tool for assembling, presenting and analysing information covering the entire municipality. An actor at a central level in the municipality, for example a safety coordinator, should perform this task, if the environmental risks are to be taken into account.

Currently the program is distributed as a part of the database RIB (The Swedish Rescue Services Information Bank), which is only used by the Municipal Rescue Agencies, and therefore it does not today reach the functions that could use it in the way it is supposed to be used. For Riskera to function as a tool for managing environmental risks, it is also very important that environmental sensitivity is included in the features of the program.

Identifiering av systemsvagheter för ökad driftsäkerhet på Oskarshamns kärnkraftverk

Lars Magnusson

Abstract

In this report the results of an investigation of the causes of production interruption at the nuclear power plant in Oskarshamn, Sweden (OKG) are shown. A description of important parts in risk management is included and the risk management work at OKG is stated. Latent conditions and missing parts of the risk management system are identified. Measures that may develop and improve the risk management work at OKG are suggested.

Summary

OKG is one of the companies in the Sydkraft Group. OKG runs three nuclear power plants, O1, O2 and O3 in Oskarshamn, Sweden. The company is owned by Sydkraft (54,5 %) and Fortum, (45,5 %).

OKG would like to improve productivity by decreasing the number of unscheduled shutdowns and by avoiding prolongations of scheduled shutdowns. In this degree project an investigation of the risk management in the area production is carried through. The objective of the project is to give suggestions for improving risk management for improved productivity.

An investigation of causes of unscheduled shutdowns and prolongations of scheduled shutdowns has been carried out in order to identify any deficiencies in the risk management at OKG. The studied shutdowns have occurred at the three reactors during the years 2000-2004. In the analyses active failures and latent conditions have been identified.

An important component in risk management is to create and support a good safety culture including a good learning culture. An effective system of learning from incidents in a company is necessary to prevent undesirable incidents and to prevent such incidents from occurring again and again. The safety culture is important because the effectiveness of the risk management is dependent on the safety culture in the company.

An extensive risk management work is carried on at OKG. Incidents are reported and analysed. Measures are taken and the experiences are documented for future use. An active work is also going on to improve the safety culture.

The analysed incidents are often caused by latent conditions that have been created at different moments by different decision-makers. One identified deficiency is that the participation and the support by personnel from OKG when contractors are performing work at the company are insufficient. Other deficiencies are that the quality of the jobs sometimes is not sufficient and that the analysis and the following-up on identified incidents are not extensive enough.

The most important suggestions for measures are:

- Try to foresee how allocation of time and personnel resources may affect the quality of performed operations.
- Prepare a system of control that makes sure that necessary elements exist to perform operations with required quality.
- When contractors make decisions or when suppliers assure a specified function OKG should take more responsibility. The competence that exists at OKG and the investigations that are made should be used to a bigger extent to influence the situation that is created by the contractors/suppliers and to support them.
- Measures that are suggested in connection to identified incidents should be more extensive so they can prevent more incidents than only exactly the same incident.

Despite the identified suggestions for improvements the risk management is very well developed at OKG. This is mainly due to the fact that there are systems for learning, for securing of quality on performed work and for development of the safety culture. Improvements are always possible and the suggested remedial measures are meant to be a contribution to a development of the risk

management work through an increased control of the risks the company faces.

Risks associated with an automatic transportation system

Cecilia Nilsson
Peter Svensson

Abstract

Today, an automated transportation system is under construction by a Swedish company. No similar systems exist to date, thus proactive risk analyses have been made. Two risk analyses have been performed; Task Analysis and Scenario Analysis. To perform the risk analyses, other transportation systems have been visited and studied. Apart from the visits, studies of relevant literature have been made to describe the importance of the organization and the design process.

Introduction

All over the world the demand for new means of transportation systems is on the rise, and new systems for personal traffic are beginning to appear on the market. One new automatic transportation system is under construction by a Swedish company. This fully automatic system will be a driverless mean of personal transportation, and will be comprised of small wagons that move on a track situated approximately 4-5 metres above ground level.

The aim of this Master's Thesis has been to find the risk picture of this automated transportation system. Today there are no such automated systems in existence, hence no previous experience from such systems exist. This is why proactive analyses must be used when trying to find the risk picture. Another aim of the thesis has been to contribute to the creation of a safe system by pointing out some of the factors that are highly significant to the safety of the system, such as organizational factors and the design process.

Passengers´ opinion of automated transportation systems

The conclusion of the literature study made, is that people aren't afraid to travel with driverless transportation systems. However, what seems to affect the attitude of travelling is the feeling of unsafety and the fear of being attacked, robbed or raped. There is also the need for quickly being able to get hold of personnel. Camera-surveillance seem to dampen the passengers´ fear and make them feel safer.

Organisation

Throughout time, experience shows that the organizational factors are the ones that have the largest impact on the safety of a system or company. Therefore, it is of great importance that the organization around this type of new personal transport systems is of a good kind. Most of the faults in a company originate from organizational circumstances. How the organization is built affects the local workplace factors and if these aren't good, human errors may lead to accidents if the defence against accidents is bad or inadequate. When working with the organizational factors, some talk about the concept of a Safety Culture. This concept consists of some different components, for example the *informed culture* - where the organisation gathers data, analyzes this and spreads it. It also means that the company management are aware about the human, technical, organizational and environmental factors that affect the safety. (Reason, 1998) The culture should also be a *reporting* one - to achieve the necessary information, and *flexible* - so that the employees can work outside their assignments when needed. That the organisation has a *just culture* is then of importance, so that the employees dare to report. All of these factors lead to the most important factor; a *learning* organisation. This kind of organization learns from its mistakes, and reforms are implemented when needed.

Design

When accidents occur the human factor often seems to be the causes, but human factors can usually be traced back to bad design. If the design had been properly made in the first place, it wouldn't have been possible to make errors at all. To be able to develop a safe system the design procedure is of utmost importance. A method from Food and Drug Administration (FDA) is being presented below. This method consists of seven steps that will help to perform a safe design, see figure 1.

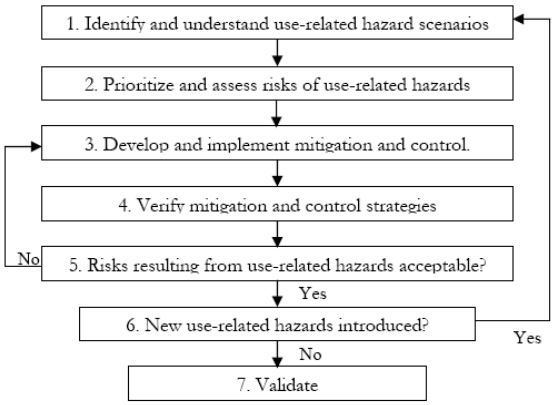


Figure 1

To be able to design the system from "scratch" gives a great opportunity to design a safe system from the beginning. Getting everything "right" the first time will save a lot of money in the end. Otherwise changes may have to be made to the system in a late stage, which can be very costly.

Valuation of risk

Most often there is no possibility to eliminate all of the risks found in a system. Therefore the risks must be evaluated before they can be managed. Some risks generate more harm than others, some risks may perhaps be acceptable and preventive measures deemed unnecessary. Decisions must be taken on what risks should be eliminated, and the preventive measures should be studied. Some measures are more effective and cost-effective than others. These questions are of importance when deciding which risks should be attended to.

Risk analyses – Task Analysis, Scenario Analysis

Two risk analyses have been performed; Task analysis and Scenario Analysis. Both risk analyses are qualitative risk analyses. The reason for this is that the studied system is under development and no systems like this exist today. Therefore no accident data or statistics of such systems exist.

The analyses were made by studying literature, by visits to similar transportation systems, by interviews and by brainstorming. The Task Analysis was performed in such a way that a passenger has been followed through a journey in the system. In every step, (one step could be "enter the car"), the risks have been identified along with suggestions to precautions. The Scenario Analysis was divided into different categories, e.g. Fire, Electricity, Climate Factors, etc. Within each category different risks have been identified and suggestions to precautions have been made. The analyses are divided so that risks/accidents occurring due to actions made by the passengers are presented in the Task Analysis and the other risks are presented in the Scenario Analysis.

Visits and Interviews

Visits were performed at systems that to some degree had similarities to the system that is under development by the Swedish company. The visited places are:
The Metro and Ørestadsselskabet in Copenhagen
The Subway (SL) in Stockholm
The Train Command Centre in Malmö

The results of the visits both contributed to the risk analyses and to a certain chapter were the experiences from the visited systems are summarised.

Conclusions

The visits as well as the literature studies show that the organization's attitude towards safety is of great importance, during the development as well as during operation of the final system. It's of great importance that the board of the company shows absolute interest in those matters, otherwise no one else will either.

In the report the risks are being dealt with on a general level. As the development of the system continues and the technical solutions get more detailed, the risk analyses should get more detailed as well.

By working hard with safety during the development process a lot of money can be saved, for several reasons. If a correct and safe construction is being made from the beginning the construction doesn't have to be changed when it's already completed. Also the risk of "bad will" - that could affect the system in case of an accident is - being reduced.

Proactive Risk Management in the City Tunnel Project. In-service training and a model for organizational risk management.

Nils Rosengren

Abstract

This thesis project aims to develop and implement an innovative curriculum, with corresponding course material, for risk management within the City Tunnel Project. Furthermore, this thesis resulted in a method proposal for organizational risk management. The model is based on the organization's current management systems and presents a solution for the implementation of risk management in the project.

Introduction

The City Tunnel is the last link in the railroad connection across Öresund on the Swedish side. The project includes a total of 17 km of railroad, rebuilding of the Malmö Central Station as well as the construction of two new train stations along the railroad. The City Tunnel Project is owned and operated by the National Railway Association (NRA). The NRA has set forth a separate organization for implementing the City Tunnel Project; this organization is called the City Tunnel Project (CTP). The CTP utilizes risk management as a tool to accomplish the goals of the project and other general requirements. Risk management is utilized in this organization, yet lacks in documentation and systematic implementation. This thesis aims to develop and implement an innovative curriculum for risk management within the CTP. Furthermore, through this thesis, a proposal for an organizational model for risk management will be put forth for incorporation into the project.

Methodology

This thesis project will begin with an inventory and assessment of the current knowledge and utilization of risk management principles in the CTP, as well as any shortcomings in the implementation of risk management on site. Parallel with this inventory, comprehensive research on proactive risk management and cultivating a safety culture within a corporation will be conducted. The initial inventory and research will result in the development of a risk management curriculum for the CTP staff with corresponding course material. Before the training sessions are carried out, the curriculum and the course material will be tested in two trial sessions. The course material will be further developed with iterative design based on the continuous evaluation of the training after each training session. The Principal Investigator (Nils Rosengren) and Per Åkesson, the CTP Project Coordinator in Risk Management, will carry through the in-service training on four separate occasions.

Following the conclusion of the training sessions, analysis of the CTP's and one contractor's management system will follow. The analysis will be focused on implementation of risk management and organization-specific factors, as well as the cooperation between orderer and contractor. The analysis builds on continuous surveys within both organizations as well as information from the discussions arising during the training sessions.

Results of the assessment point out certain problems and difficulties with risk management in the City Tunnel Project. Risk management work was well-received on the higher levels of management, but has shortcomings on the operative level. Due to these shortcomings, a proposal for an organizational model for risk management is proposed. The model is based on the organizations' current management systems and presents a solution for the implementation of risk management.

In-service training

The curriculum is divided into four parts, where part one and two account for what risk management is and why it is important to the City Tunnel Project. Here theoretical concepts such as safety culture and learning organization along with models for systems view and decision-making are explained. Part three accounts for the internal risk management process from the CTP management system. Part four accounts for the contractor's risk

management process, i.e. how the contractual demands placed on the contractors shall be fulfilled. Furthermore, after every training session some good discussions arose.

The course material contains several illustrating examples, from the City Tunnel Project as well as from other current, extensive construction projects in the region such as the construction of the Öresund Bridge and Turning Torso in Malmö.

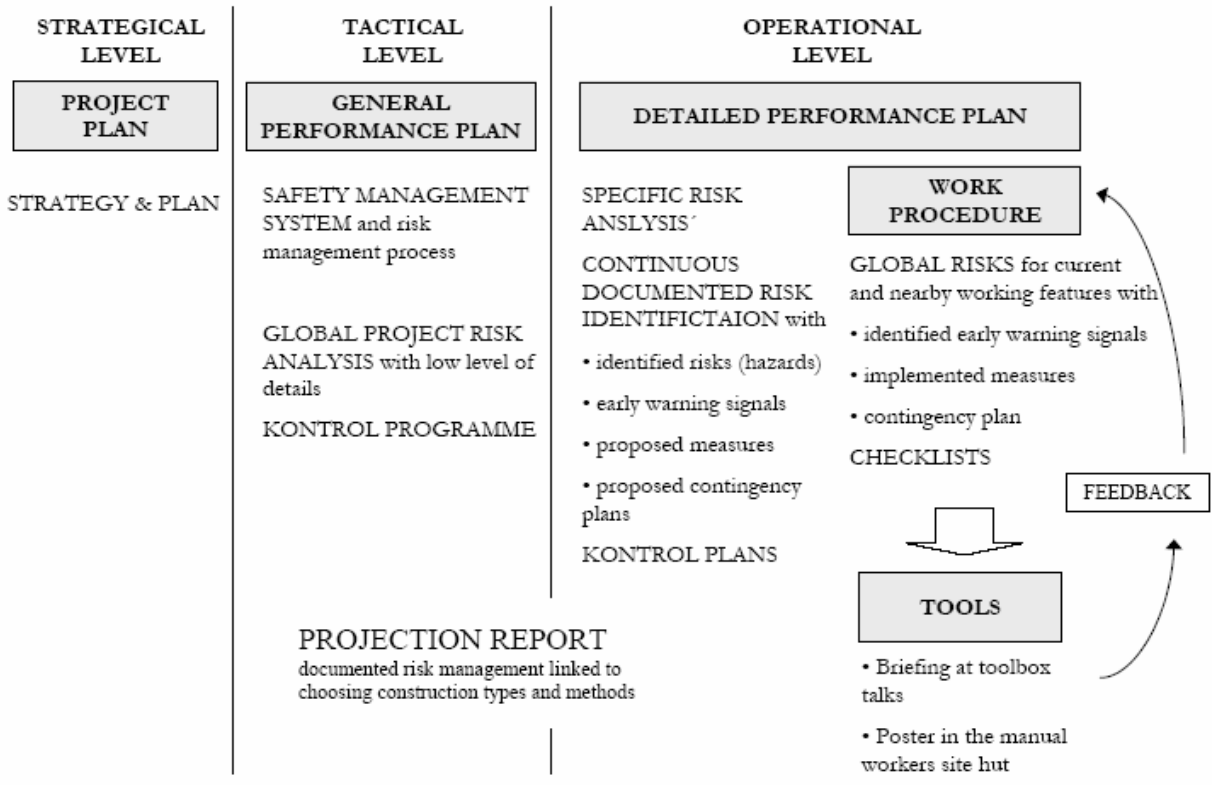
Model for organizational risk management

The project's global policies and strategies for risk management shall be based on strategic level in the project plan.

The governing document on the tactical level shall account for a global project risk analysis with a low level of details. It shall also contain a general program for control. On the tactical level the project's safety management system and risk management process are usually described in a separate document, here in the Project Handbook.

On the operational level, more specific risk analysis will be carried out for every working feature. The continuous, documented process of risk identification will contain identified risks (hazards), early warning signals, proposed measures, and proposed contingency plans.

On the operational level, specific work instructions are established in detailed performance plans for critical working features. These documents are established in order to spread information to the manual workers about the construction types and methods. The detailed performance plans will contain an overall description of risks for the current and nearby features along with implemented measures and approved contingency plans. This information comes from the continuous process of risk identification and the projection report.



In order to ensure that the information reaches the manual workers the detailed performance plans are to be briefed prior to the initiating of the work feature.

Project risk management

To achieve and implement effective risk management in a project the safety management system has to be well integrated into the project's other management systems. To achieve and maintain a high level of safety it is important to have a global approach towards the project's processes and not only focus on details. This global approach can be achieved by linking the risk management activities to other areas such as quality management, environment, and work environment.

To reach and maintain a good organizational safety culture, the cooperation between orderer and contractor is critical. Problems arise because orderer and contractor have different viewpoints of the same project, and their opinions may differ. Therefore, it is important that both parties work towards ensuring the accomplishment of the same goals, i.e., the project goals. In order to ensure the successful implementation of risk management, the cooperation between the stakeholders must be given top priority.

Initially in a project the balance of information is skewed towards the orderer side. This balance shifts towards the contractor as the project proceeds. In order to succeed in the interaction between orderer and contractor it is of outmost importance that the balance of information is even. This can only be accomplished by open dialogue and communication as well as thoughtful progress, incident, and accident reporting resulting in both parties sharing the same information.

If the safety management lacks commitment and motivation in the organization the safety management activities can be temporarily focused on the work environment. Safety in the work environment is closely governed by legislation and shortcomings in safety are evident in the prevailing situation in the work environment.

Another method to improve the commitment to and motivation for safety is to introduce some kind of reward system for accident-free performance.

Discussion

The next training activities are risk management training for parts of the contractor's organizations in consultation with the CTP's work supervisors. These training activities should be focused on spreading risk awareness, the communication and the interaction in and between the organizations. It is important that the training has practical application. To ensure this, risks and incidents from the City Tunnel Project can be used as examples.

The model presents a possible working procedure and flow of information between levels and activities in the risk management process. A condition for the method proposal to work is that the separate parts of the risk management process are correctly performed.

A problem that derives from the above mentioned reward system is that information about incidents and accidents can be withheld and not reported. Another approach is to reward not incident-free performance but the number of reported incidents. The number of reported incidents can then be compared to the number of occurred accidents. This will increase the motivation to report incidents and accidents and thereby facilitate and improve the safety management.

Index model as a basis for risk assessment

Jakob Schlyter
Daniel Selvén

Abstract

The purpose of this Master's thesis was to investigate which factors that influence the size of a loss that occurs as a result of fire or explosion. The study is based on data supplied by the insurance company If. Further on, the results shall be implemented in risk assessment when insurance premiums and reinsurance requirements are determined.

Introduction

For an insurance company it is of great importance to assess the risk it bears when insuring a client. If the client has insured great economic values the importance increases since an unforeseen risk due to an inadequate assessment can jeopardize the insurance company's existence. If target clients with a turnover of more than 500 MSEK, resulting in many cases of large and valuable buildings needed to be insured. Therefore it is crucial to get a proper understanding of the risks that are insured.

At If a risk engineer describes the risk in an industry building and estimates the biggest loss that can occur in the building, i.e. the largest amount the insurance company might be forced to pay at a single occasion (EML). The risk description and the EML assessment determine whether the risk (the building) is interesting, and if this is the case, what premium it corresponds to and if it should be reinsured or not.

There are many difficulties associated with such a risk assessment. Companies have become more complex and value intensive as the technical development has progressed. This results in high demands on the risk engineers who are responsible of making as accurate risk assessments as possible. If the risk is overestimated the premium might be too expensive and the customer chooses another insurer, but if the risk is underestimated the profit for the insurance company will vanish. Today there are no standardized ways to perform risk assessments. Every risk engineer does his own individual assessment.

To facilitate the risk assessment for the engineers, two different tools has been developed as a result of this thesis. One should be used to derive a value for the fire frequency, while the other tool should be used to estimate the fire spread potential in an industry. These are two key components in the risk evaluation.

Method

An existing model has been used to derive a value for the fire frequency in a building1. This model does not take into account the type of industry, only to the floor area in the building. Studies have proved that the model is useful for engineering purposes1. To get a more object-specific fire frequency the existing model will be updated with information from earlier fires in the object.

The second tool is a model that provides an estimate the fire-spread potential within a building based on eight different parameters determined by the engineer.

The model was developed by using the generalized procedure for ranking fire safety parameters proposed by Watts2. Which parameters that should be included in the model was determined through a statistical examination of If´s loss statistics combined with literature studies.

Weights to the eight parameters were assigned using Multiple attribute decision making (MADM) methodology and by using an expert panel. MADM is used to facilitate decision making when the decision criteria are

of different significance and are expressed in different units3.

By using a given set of decision criteria an index for a fire's potential to spread for a given industry building can be calculated using current conditions. The tables that are to be used are presented below.

Survey items for the parameter Building	Weight [A]	Grade [B]	Product A*B=
Building class	0,34		
Fire-rated wall	0,33		
Area of fire compartment	0,32		
	Sum		

Survey items for the parameter The staff's possibilities to extinguish a fire	Weight [A]	Grade [B]	Product A*B=
Ability to intervene	*0,5*		
Fire fighting equipment	*0,5*		
	Summa		

Parameters	Weight [A]	Grade [B]	Product A*B=
Building	*0,16*		
Ventilation	*0,12*		
Time to the fire brigade arrive	*0,08*		
The staff's possibilities to extinguish a fire	*0,09*		
Automatic Sprinkler	*0,13*		
Detection system	*0,09*		
Fire load	*0,17*		
Rate of fire development	*0,16*		
	Sum [I]		
Index for the potential for a fire to spread	***=5-I***		

Figure 1. Calculation tables for fire-spread index

Before the index can be calculated the parameters "Building" and "The staff's possibilities to extinguish a fire" need to be graded by studying a number of predefined survey items.

The index is calculated by grading all parameters and summing up the products. To make the index value logical, i.e. bad grades on the parameters correspond to a high index, the sum of the parameters should be subtracted from 5.

The fire frequency is calculated by studying the object's total floor area. With information of the number of fires that occurred during a given time period, the frequency can be updated using Bayes' Theorem. The procedure are described below and the tables that are to be used are presented in fig. 2:

1. Fire frequency is calculated
2. A continuous priori distribution is assumed to follow a gamma distribution
3. The parameters α and β are calculated and updated
4. Finally the updated fire frequency is calculated

Figure 2. Calculation tables for fire frequency

To assess the usability of the ranking model, a number of people tested the model on two different objects. The aim of the case study was to establish an understanding of the precision of the model. The result from the study indicated that the ranking model can be used in practice.

Conclusion

To be able to assess the risk in an industry the fire frequency and the fire spread potential must be combined with expected cost of loss for the industry.

In this thesis the two individual tools were developed, however, to develop a model for combining the two with industry data was outside of the thesis' scope.

As a result of this no complete quantitative risk assessment model is developed within the theses. However, a major step forward is taken by developing the two tools; the first to assess the fire frequency and the second to determine the fire spread potential in an industry building. These two tools can each be used to rank different industries between themselves.

Figure 2. Calculation tables for fire frequency

Building	Area [m^2]	Fire frequency [λ]	Time-period (year) [t]	Amount of fires that occurred during the time period t [r]
		(Area) x (0,07 x (Area)$^{(-1,48)}$ + 6E^{-6} x (Area)$^{(-0,05)}$)=____		
		(___) x (0,07 x (___)$^{(-1,48)}$ + 6*10^{-6} x (___)$^{(-0,05)}$)=____		
		(___) x (0,07 x (___)$^{(-1,48)}$ + 6*10^{-6} x (___)$^{(-0,05)}$)=____		

Building	Apriori			Posteriori		
	Fire frequency E(λ)	B	α	α´	β´	Fire frequency E(λ´)
		1	β x E(λ) =____	α + r =_____	B + t =____	α´/ β ´ =___
		1				
		1				
Fire frequency						Σ=_____

To improve the ranking model's precision and applicability further a separate model should be developed for each industry, in order to be able to take the industry specific parameters into account. Furthermore, to assess the risk in a specific industry in a better way and to improve the basis for decisions regarding premiums and EML, a model which accounts for fire frequency, fire spread potential and expected cost of loss for that industry needs to be developed.

References

1 Keski-Rahkonen et al. "The Ignition Frequency of Structural Fires in Finland 1996-99". VTT Building and Transport, Finland

2 Watts. John M. Jr, "Fire Risk Ranking". SFPE Handbook of Fire Protection Engineering, 2nd Edition, Page 5-12 – 5-26, 1995

3 Yoon & Hwang, "Multiple Attribute Decision Making". Thousands Oaks, Sage Publications 1995

Modelling of forest growth, soil acidification and liming in Asa Royal Park

Jonas Båvall

Abstract

Acidification of forests in Sweden may lead to negative effects on tree health and tree growth. Aluminium, that is released when soil acidification occurs, is toxic to tree roots, where the risk for effects on the trees is expressed by the BC/Al ratio. Forest limings can be made for counteracting the acidification of forest soils. The model ForSAFE is used for simulating forests, and a subroutine for simulating limings is attached to ForSAFE. Dissolution of the liming mineral is modelled as deposition of calcium and magnesium ions. Simulations of ten forest stands in Asa Royal Park with and without liming are made. According to the simulations the BC/Al ratio was increased, and hence the risk level for tree damages was lowered with the limings. There was no risk for tree damages when forest sites with liming were simulated. Without liming one of the ten simulated sites is exposed to a considerable risk for negative effects on the trees.

Background

The forests are important natural resources for wood production, but also for recreation and other purposes. In this report maintenance of the wood production will only be taken into account. The forest industry is a major industry in Sweden, and a change in tree growth will affect the Swedish economy. The value of standing timber and forest land in Sweden is approximately 600 billion SEK. Since large economical values are bound in the forest an optimal management is crucial for maintenance of the economical development of the forestry industry.

The word risk can be used in different ways depending on in which perspective the word is used. In this report the definition of business risk made by DeLoach is used. Business risk "is the level of exposure to uncertainties that the enterprise must understand and effectively manage as it creates value" (DeLoach, 2000). In the forestry there are decisions made concerning economical values and risk management.

Forests in Sweden are exposed to acidification. The acidification of forest soils decreases the pH in the soil solution and increases the aluminium solubility. Increased aluminium concentrations influence the health of the forest and can cause damages to the trees. Liming of soils and watersheds counteracts the acidification (Warfvinge, 1997).

The BC/Al ratio is the ratio between the base cation concentration and the aluminium concentration. With a low BC/Al ratio there is a risk for the status of the tree health due to increased mortality of the trees from storm fellings and disturbed nutrient uptake. In this report the risk for damages is divided into risk levels: high, intermediate, low and no risk. There is a threshold value for the BC/Al ratio corresponding to each risk level (Warfvinge and Sverdrup, 1995).

Risk level	BC/Al ratio
High	0.4
Intermediate	0.9
Low	1.5

Table: Threshold values of the BC/Al ratio for risk levels

Objective

The objective of the report is to determine how the risk for negative effects on trees due to acidification is affected by forest liming. The risk is investigated with computer simulations by studying the BC/Al ratio in the soil solution. Simulations with ForSAFE are made with and without liming for monitoring

the forest status in ten test sites located in Asa Royal Park. The simulation results are statistically investigated and comparison is made between the results with and without liming.

Approach

The ForSAFE model (Wallman, 2004) simulates forest ecosystems, and it is an integrated model consisting of four sub-models. The sub-model PnET-CN is developed for simulation of tree growth, the SAFE model describes the soil chemistry, the model DECOMP simulates the decomposition of litter and soil organic matter, and a modified version of the PULSE model is utilized for simulating the soil hydrology. In ForSAFE the models are linked together so the different parts of the model interact with each other. The program is written in the computer language Fortran 90.

When liming occurs solid liming mineral is added to the soil. The mineral dissolves into the soil solution, where the release of ions from the mineral is simulated as deposition of calcium and magnesium ions. The type of added mineral, the particle size and the concentrations of ions in the soil solution determines the rate of dissolution. With the routine attached to ForSAFE, dissolution of the liming minerals calcite, $CaCO_3$, and dolomite, $CaMg(CO_3)_2$, can be modelled.

In the statistical examination of the result a "student's t-test" is used (Blom, 1970). With a "student's t-test it is possible to determine with which probability a stochastic variable adopt a value within a certain interval. The explored stochastic variable is assumed to be normal distributed. The t function is used in the "student's t-test", and it is a continuous probability function.

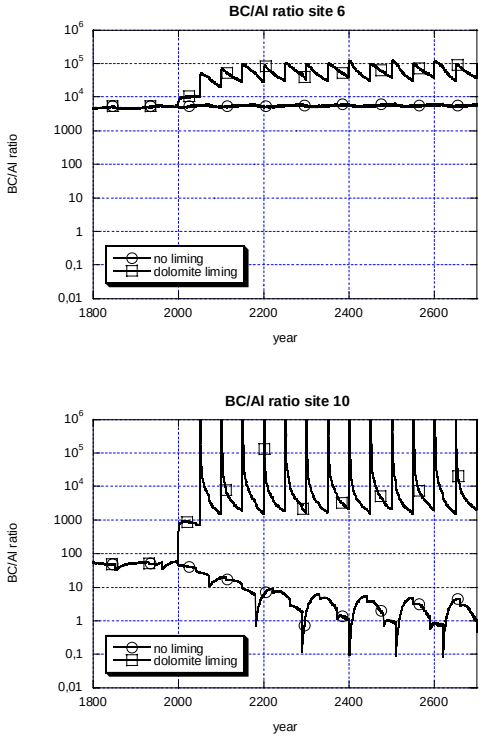
With a "student's t-test" hypothesises can be proved, not proved or rejected. The hypothesis states that the estimated value of a stochastic variable is within a confidence interval. The test is made on a certain degree of confidence. If the tested value or values are within the confidence interval the hypothesis is proved on the specified degree of confidence (Blom, 1970).

Simulations

With ForSAFE ten sites in Asa Royal Park are simulated. The input information to the program specifies the condition of these sites and the simulated scenario with and without liming. Asa Royal Park (Swe; Asa Kronopark) is an area with forest land located in southern Sweden. Norway spruce is the modelled tree species. The simulated time interval ranges from 1800 to 2700, and a forest management scenario for this period is simulated. The nitrogen and sulphur deposition levels increase from 1800 to 1980, and a decrease occurs from 1980 to 2700. High sulphur and nitrogen levels correspond to deposition with high acidity. In ForSAFE harvestings and thinnings are simulated as biomass removal from the forest. Each tested site is simulated with and without dolomite liming. The time interval between each liming is 50 years, with the first liming occurring in year 2000.

Results

The ten simulated sites are in various extents exposed to acidification. In the sites most affected by acidification, the BC/Al ratio decreases remarkably over time when no dolomite is added. The BC/Al values are held on a stable level in the other sites. According to the BC/Al criterion there is a risk for effects on tree health in one of the ten simulated sites. Site no. 10 is exposed to low risk, and the other sites are exposed to no risk.



Figures: BC/Al ratio progress of two representative sites with and without dolomite liming.

The effects of all simulated sites show an increased BC/Al ratio when liming mineral was added, where the values of the BC/Al increase are assumed to be normal distributed. A student's t-test is used for calculating the probability that the BC/Al ratio is increased more than 1.5 due to liming. The criterion for the low risk level is that the BC/Al ratio undergoes 1.5, so if the BC/Al is increased more than 1.5 by adding dolomite, the forest is exposed to no risk after the liming. According to the student's t-test, the probability for a BC/Al increase more than 1.5 is in between 90 % and 95 %.

Conclusions and discussion

The BC/Al ratio increases when liming with dolomite is made. Before liming the site no. 10 was exposed to a low risk for tree damages, and the other sites were not exposed to a considerable risk. In site no. 10, the risk was lowered from low risk to no risk when the limings were made. According to the simulation, liming was a successful method for lowering the risk for negative effects on tree health where a considerable risk occurred before liming.

The precipitation and the deposition data are general data valid for the area where Asa Royal Park is located. In reality there are local variations in these data between different sites. Taking into account the local variations of deposition and precipitation levels may change the simulation result from the investigated sites. Deposition data are generated from forecasts made for the years from now until 2700. The state of acidification is much influenced by the deposition levels, so with forecasts made on so long time basis the uncertainty in the simulation results are very high.

Only ten sites located in Asa Royal Park have been simulated. The soil conditions, the climate, and other conditions vary all over the Asa Royal Park and even larger variations occur in different parts of Sweden. Therefore generalizations to local or regional level are not possible to make.

The statistical calculations made in this report utilize simulation results from a few points of time in each simulation, even though the ForSAFE simulations generate results for each month from 1800 to 2700. Calculations taking the BC/Al ratio of all simulated months into account are required for a more reliable risk classification of the sites. A method for such calculations is not developed in this report.

References

Blom, G.: 1970, *Statistikteori med tillämpningar (Statistics theory with applications, in Swedish)*, Studentlitteratur, Lund.

DeLoach, J. W.: 2000, *Enterprise-wide Risk Management: strategies for linking risk and opportunity: an executive summary*, Pearson Education Limited, Harlow.

Wallman, P.: 2004, *Modeling nutrient cycling and sustainable forest growth in a changing world*, Phd thesis, Lund University, Lund.

Warfvinge, P.: 1997, *Miljökemi: miljövetenskap i biogeokemiskt perspektiv (Environmental chemistry: environmental science in a biogeochemical perspective, in Swedish)*, 1.5 edn, KFS, Lund.

Warfvinge, P. and Sverdrup, H.: 1995, *Critical loads of acid deposition to Swedish forest soils: methods, data and results*, Reports in ecology and environmental engineering, Report 1995:5, Department of Chemical Engineering II, Lund University, Lund.

Analysis of methods for municipal risk analysis – establishment of action programmes according to the legislation on accident prevention and protection

Maria Cucas
Lisa Noppa

Abstract

According to the new legislation for accident prevention and protection, which took affect January 1st 2004, all Swedish municipalities have to establish action programmes for accident prevention and the fire service. Municipal risk analysis should constitute the foundations for these action programmes. The purpose of this report is to describe and meet the requirements on municipal risk analysis and give proposals on the structure of these analysis. This has been made by doing interviews and by sending out questionnaires to a restricted number of municipalities.

Introduction

According to a new Swedish legislation for accident prevention and protection, municipalities in Sweden have to establish action programmes. These programmes shall state the goals for the municipal undertakings and present the risks of accidents that could demand rescue actions from the fire service. In accordance with an agreement between the Swedish government and the Swedish municipal association (Svenska Kommunförbundet), potential risks should be analysed to be used as a foundation for the municipal undertakings. Municipalities in Sweden today are in need of useful and understandable tools to be able to create risk analysis, which to an extent underlies the establishment of these action programmes. The methods of risk analysis today is mostly adjusted for the high risk processindustry.

To support the municipalities the Swedish Rescue Services Agency has presented a model as a support for the establishment of the action programmes. However, this model does not consider the design of risk analysis.

Methods

In this work, the requirements were described regarding the design of municipal risk analysis according to the new legislation for accident prevention and protection, and on the basis of the municipal need of support. According to these problems proposals on the designprocess for municipal risk analysis are given This master thesis in risk management and safety engineering will also be included in a course held by the Swedish Rescue Services Agency called "Kurs A - Metoder för Samhällsinriktat säkerhetsarbete".

In order to analyse the current situation interviews and questionnaires have been carried out. Due to the restricted time for this project only a restricted number of municipalities have been surveyed. The municipalities which were chosen are Laholm and 19 municipalities in the region of Västra Götaland

Identified problems

The problems which were identified were divided into two groups: The structure of the organization (for establishing action programmes and designing risk analysis) and problems regarding methods for designing municipal risk analysis. Some of the identified problems were:

- Coordination on local and regional level between administrations and legislations
- The lack of competence for carrying out risk analysis and making decisions based upon these analysis

- The lack of concrete methods and useful tools for doing municipal risk analysis

- To integrate the vulnerability when doing risk analysis

Proposals on municipal risk analysis structure

The group established for handling the municipal safetywork which includes the establishment of action programmes and the design of risk analysis should consist of a small group. Research indicates that the effectiveness within a group decreases the bigger the group gets. Therefore, six or seven persons could be an optimal number. The composition of this group should reflect the current municipal structure. To achieve a higher knowledge and new angles of approaches it would be a benefit if as many municipal administrations as possible are included in the group. To fulfill these wishes the group can, as a suggestion, be divided into an inner group and smaller outer groups.

Due to the existing problem of finding adequate competence within one single person, a group is recommended. The importance of education and continuous training of the available personnel must be pointed out. This training should also include specific education on risk analysis methodology. Some municipalities can not afford this, so it could be an alternative to arrange some internal training.

The new legislation for accident prevention and protection does not require the vulnerability to be analyzed and the structure of a vulnerability analysis is not outlined. If the vulnerability is not taken into account the final action programmes will not achieve the legislation goals, which states that citizens all over the country hold the rights to satisfactory and equivalent protection against accidents. Therefore the action programmes always should be based on the vulnerability and needs of the municipal citizens.

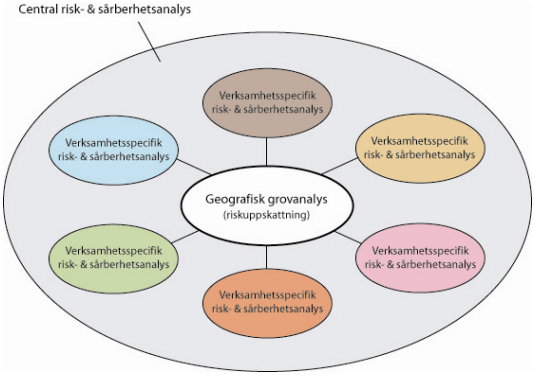


Figure 1. Proposal on how to organize municipal risk- and vulnerability analysis

When designing the risk- and vulnerability analysis the group should, by way of introduction, carry out a rough analysis that covers the current risk- and vulnerability situation of the municipal in a comprehensive way. In the next phase all municipal administrations should carry out a specific risk- and vulnerability analysis that covers their respective sphere of activity. On the basis of these two analyses the inner group performs a common, coordinated and central risk- and vulnerability analysis. The purpose of this analysis is to combine and integrate the results from the two analyses, which were previous mentioned. If the risk- and vulnerability analyses are structured as above it will hopefully lead to a comprehensive image of the risks and vulnerabilities in the municipal.

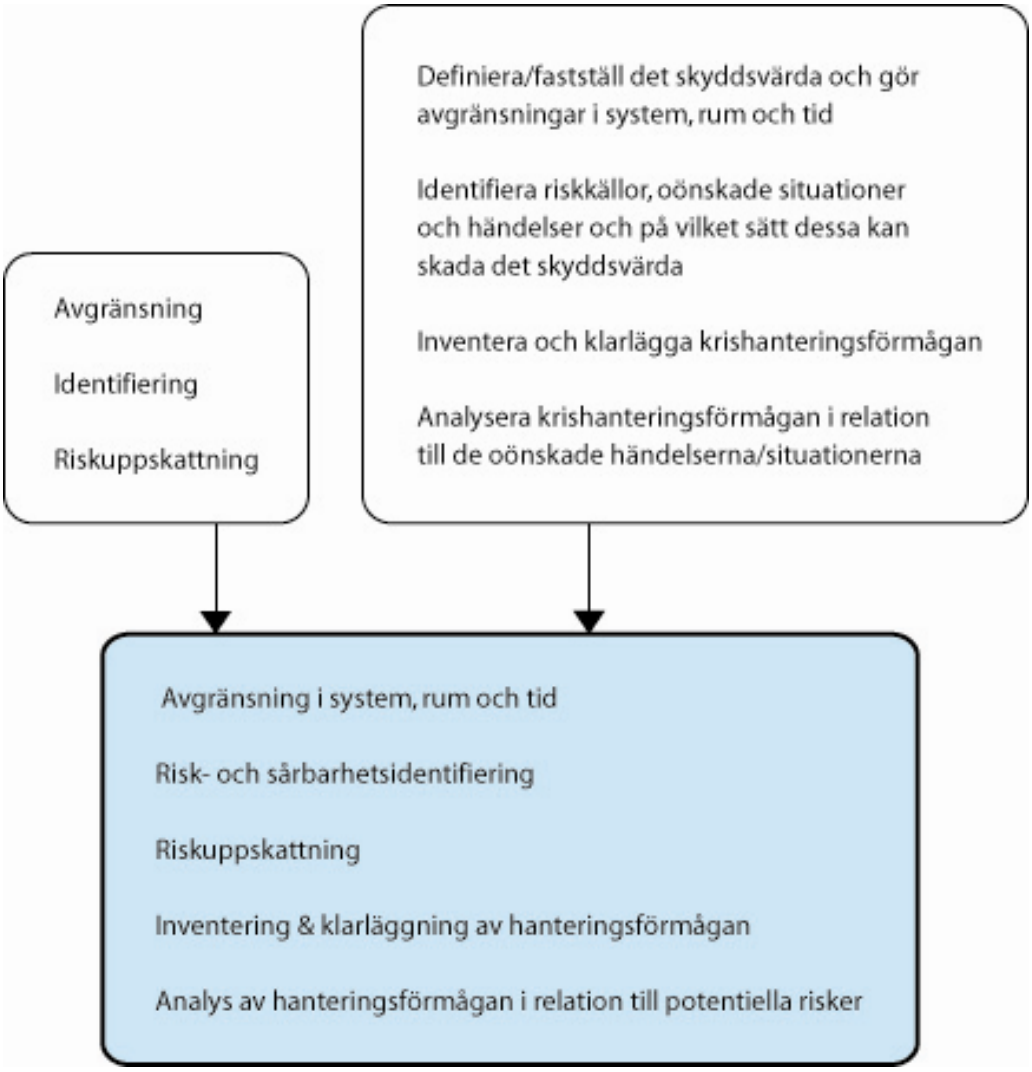


Figure 2. General sequence of work for designing risk- and vulnerability analyses

A general sequence of work for designing risk- and vulnerability analyses is presented on the basis of two different models: IEC: s model of risk analysis structure and four basic steps for vulnerability analysis. The general sequence of work is supposed to be able to be applied on the municipal administrations specific risk- and vulnerability analysis as well as on the common, coordinated and central risk- and vulnerability analyses

A foundation to a Management System aimed for the Wood Industry – A systematic fire protection tool

Henrik Edwall
Kim Wikborg

Abstract

The aim of this report is that the tool produced shall make it easier for enterprises to start up and get continuity in their fire protection. Not only to comply with legislation and insurance related demands but also, perhaps even more important, in a longer perspective lead to a higher level of safety. For this purpose a specific tool has been created. The tool is based on the internal and external demands that this type of industry is living with. Also the specific needs and conditions have been considered when developing the tool. The tool contains eight main areas: *objectives and policy*, *documentation*, *action plans*, *organization and responsibility*, *organizational learning*, *safety instructions and procedures*, *service and maintenance procedures*, *control and follow up*. They all, together, contribute in developing safer activities.

Background

The Swedish Civil Protection act has been changed. This new act emphasizes the individual's responsibility for fire protection. The municipality decides on how supervision is to be conducted and how often written documentation is to be submitted. This together with the demands from If Insurance, to work out a simple and practical tool that can be used to facilitate the loss prevention, was the background of this master thesis.

Safer activities

A study of actual literature, statements from safety specialists within trade and industry and Scientists at the Department of Fire Safety Engineering was carried out. The study identified three main factors as most conclusive when creating safer activities:

- ✓ *A continuous safety work,*
- ✓ *A genuine safety culture* and
- ✓ *A safe construction*

A continuous safety work is important to make it possible to identify new risks as well as on how to maintain a high safety level. There might be changes in the specific needs or conditions present that have to be considered. Hopefully by having a continous safety work this will be brought to daylight and managed with a correct approach. To make all employees involved and interested in safety issues the creation of a genuine safety culture is essential. By increasing the awareness and commitment among the employees they will play a important role in how to create safer activities. Employees that are aware and enthusiastic are vital in the loss prevention. How to design a safe construction is often regulated in the legislations. To limit the impact of an accident or a near accident active and passive technical installations and accurate constructions are vital parts.

Management system

To interact these areas is difficult. Studies of advantages and disadvantages in the work with a safety management system pointed out that this way of handling the problem was correct. By working with a safety management system coordination and control is made easier. And this might facilitate the goal of achieving a high level of these three areas. With all this as a base a draft of a safety management system was created.

Actual situation and needs

The next step was to form the system to fit into the needs of the wooden industry. Visits with interviews gave us a picture of what possibilities and requirements the industry had to work with this system. How the entity and its organization were built up and also what type of risks they had were important factors to understand their situation. The questionnaire gave us a clear picture of how far they had reached in their fire protection until today, and what areas that needs to be improved. With this new input the first draft could be updated and the tool adjusted to the actual situation and need. The tool that has been created contains eight main areas: *objectives and policy, documentation, action plans, organization and*

responsibility, organizational learning, safety instructions and procedures, service and maintenance procedures, control and follow up.

Modification is needed

Important though, is to realize that the tool that is created in the report it self does not lead to an improved fire protection level. The tool has to be adjusted to the specific situation at each site and engagement in the work has to be achieved before it is possible to reach any results. By identifying and analyzing legally binding legislation, specific physical and organizational risks, the actual needs together with existing conditions, personnel etc. the tool can be adjusted to fit in to the actual organization.

Conclusions

Some major conclusions stood out throughout the project. Most significant of how to success showed out to be the level of management commitment. Without an active management involved in developing the systematic safety work it is very difficult, if not impossible, to succeed.

Also the level of competence and education within all levels of the enterprise affects the motivation that the employers have of safety related issues. Education and training therefore, according to us, should have top priority.

Another conclusion was that the documentation has to be amended. Today the documentation was very poor. This is important not only to improve the internal communication, but also to be able to measure that what is done really ends up with the intended result. Today documentation also is needed to fulfil the new legislative demands.

During the visits a great need of guidelines from higher levels in the company, alternatively from external experts like insurance companies, was noticed. Starting up or improving the systematic fire protection requires resources that today did not exist. With our tool, there now is support that can satisfy this need.

County action plan – A guidance to the work of accident prevention with focus on rescue service

Magnus Kullstam
Andreas Nilsson

Abstract

Based on a new Swedish legislation for accident prevention and protection, this report is thought to be a guidance of making a county accident prevention plan. This work is following the process introduced by the Swedish Rescue Service Agency, Räddningsverket.

Introduction

January 1st 2004 a new law came in order. The purpose with the law is to stimulate the counties and to give them an opportunity to create a safety work out of their own ambitions. One step in this direction is that the law stipulates that the counties have to create an action plan for their work with protection for accidents, both concerning prevention and rescue service. This plan should be based on the risks for accidents that exist in the county.

The Swedish Rescue Service Agency has presented one possible way to work, in form of a process (see figure). That process creates a basis for this project since several counties also will use it in their work. This report is meant to work as help in the work with protection for accidents, with focus on accidents that involves rescue service.

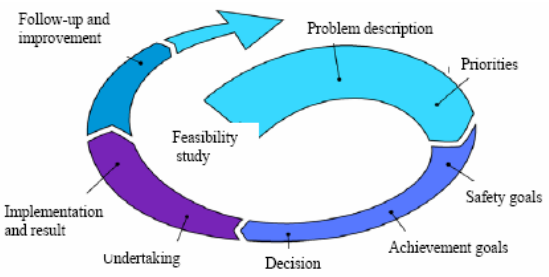


Figure: *"The process", by The Swedish Rescue Service Agency*

Feasibility study

The purpose of this first step of the process in creating an action plan for protection against accidents is to create a starting point for the forthcoming work. This means that the ones that are involved in the work should discuss the definition of certain words, for example accident and safety. They should also look how the county's development has been and thought to be in the future.

Problem description

The county has to describe the risks of accidents that occur and that may lead to a rescue effort. This can be made in several different ways concerning the risks complexity and the county's ambitions. Statistics and risk analysis are two possible tools to use in the work of identifying the different hazards. Statistics are more suitable in finding the more ordinary hazards while risk analysis is more suitable in the work of identifying the larger and more rare hazards. The risks of accidents have to be presented in an understandable way. One tool to do this and to describe the risks geographic position is to use GIS (Geographic Information System).

Priorities

A priority among the identified risks has to be done. For example is a valuation between life, property and environment in place. When the decision makers make the priorities they have to consider the needs that the people in the county have and also what demands other legislation states. The decision makers should know that different factors affect all peoples risk perception. The reasons for this are found both in the different persons personal backgrounds and different experiences and in the risks different characteristics, for example if the risk can be affected or not by the person. This leads to that no risk analysis be completely objective, since the analyst also will be affected of these factors.

The decision makers have to decide if different risk or different groups in the society should be prioritised, for example young people, elderly or the ones with lower social status. One tool that can be helpful in this decision is a cost/benefit analysis.

Safety goals/Achievement goals

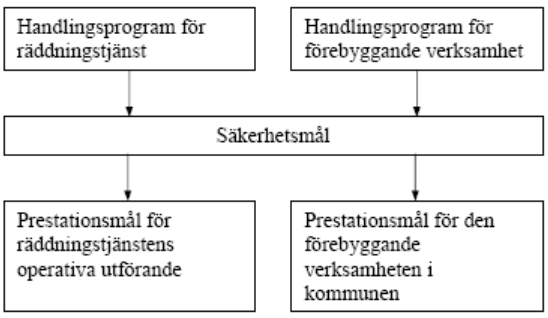
Besides describing the risks of accidents that may lead to a rescue effort, the county has to set goals for the activity and also state the county's ability to carry out rescue effort. The safety goals should stipulate what the county would like to achieve at the citizen and the achievement goals should describe how the county plans to reach the set safety goals. The use of a protection analysis to identify the different prevention measures can be a good help in this work.
Follow-up and improvement
To make sure that the development pushes forward it is important to make sure that work that has been carried out is evaluated. This is possible to do in a number of different ways. Depending on what to evaluate and which method that chooses, the data needed can be collected in different ways. One possible way to evaluate the work that is carried out in the counties concerning accident prevention is to use a goal fulfilment method.

Conclusions

To identify the risks that exist in a county, statistics and risk analysis should be used. By combining these two it is possible to identify both the ordinary and the more rare hazards. If the accidents that happens today do not already get registered this should be initiated to create more reliably statistics in the future.

The decision makers should now that people's perceptions of risks differ among them. The authors' proposal is that the priority is made combined with the acceptance of goals. This can be done in the way that the employers present several goals and the decision makers then make the priority by accepting some of these.

The safety goals that should describe what the county would like to achieve at the citizen suggests to be joined for the two action plans – prevention and rescue service (see figure).



The rescue services ability should be described in the action plan and this should be done in terms of time until the distressed is reached by a rescue squad, the rescue personals knowledge and the resources needed. The knowledge can be described in a task catalogue to insure a high quality.

The work with protection for accidents is meant to be a systematic work and therefore always lead to improvements. A suggestion is therefore that the counties in the first round of the process use existing statistics and combine that with a Preliminary Hazard Analysis to identify the largest risks. To get more reliably statistics in the future, the counties should initiate registration of all accidents, if that is not already the case. A few of the risks that have been identified with Preliminary Hazard Analysis can be examined more carefully with some other kind of risk analysis later on. The risks can preferably be presented in a Geographic Information System.

Ability is tentatively described as time until a rescue squad reaches the victim, plus knowledge and resources at the rescue squad. The goals for the rescue squad should therefore be formulated in terms of how these factors will be improved during a time period. The rescue squads knowledge can be described with a task catalogue. To create a clearer connection between made priority and expected result, the priority should be done as the goals are formulated and decided. The safety-goals that the county has to stipulate suggest be comprehensive and joined for both of the programs, prevention and rescue service.

It is easily done that the focus of the work with protection for accidents ends up on the written document that is to be sent to concerned parties for examination, when it in real is the actual work to prevent and limit accidents that's important. This is one of the reasons why there are big benefits with combining the two programs into one. There are usually measures concerning both prevention and rescue service that can be done to reach a set goal.

Disabled peoples risk in public buildings – evacuation

Martin Möller
Göran Nygren

Abstract:

This article is a summary of the report "Disabled peoples risk in public buildings - evacuation". The report is a part of the Master of Science in risk management and fire safety engineering at Lund Institute of Technology. The aim of the report is to examine the level of risk to disabled people in public assembly buildings in Sweden. The project will investigate what level of risk disabled people are subject to in these buildings, and to conclude if the risk of disabled persons is higher compared to persons with no disabilities. This was done through literature studies, interviews and by the use of a model that was developed by the authors. The analysis is presented in the report as a qualitative risk analysis. In the report, some risk reducing actions are suggested. The purpose of the thesis is also to apply and develop the author's knowledge within risk assessment and management. The aim is also to contribute with new aspects in the area of disabled people and highlight the huge dilemma that exists in the connection between disabled people and safe evacuation.

Introduction

Today's society is changing! Previously, Sweden was more or less a country where the value of humans was due to the contribution they gave to the society (a simplified image). Today we are leaning towards a more human and equal society where people have the same values and rights. The individual citizen contributes with what he or she can to the society. One of the today's aims is that every second person in a leading position should be a woman, both in politics and within organisations. These changes also include disabled peoples right to get access to public buildings from which they used to be barred due to technical barriers inherent in the building design. By a new legislation, these barriers will now be overcome. This and the old legislation makes all humans more equally valuable according to the Swedish law and gives them the same rights to participation and equality in society no matter what physical condition he or she has. It is considered as discrimination not to allow disabled, dysfunctional or other weak people to get access to the public buildings. This since they are not given the same opportunities as the rest of the citizens. This also applies in evacuation situations, which this paper is addressing. The Swedish legislation does not differentiate people. Therefore does the same acceptable risk level apply to disabled people as to people with no disabilities. The total amount of disabled people in Sweden is today approximately eighteen percent of the population.

A public building can be explained as a building that the public has access to. Examples of public buildings are: libraries, theatres, restaurants, commercial buildings and other buildings that intend to serve or be used by the public. A public building does not include dwelling (houses and apartments) and working places.

In December 1993, the United Nations stated rules for disabled people and Sweden has been an instigator for these rules. The rules will give disabled people within the U.N. nations the same freedom and rights as other citizens. As a step towards these rules, the Swedish government accepted a proposition called "from patient to citizen" from the parliamentary in May 2000. Amongst other things, the plan of actions consists of concrete goals that existing public buildings and public places should be available for disabled people by year 2010, at the latest. It is obvious that the problem of access *in to* public buildings is taken into consideration, but the safety of evacuation *from* the buildings is poorly considered. Do disabled people have a satisfying evacuation when an accident occurs? Disabled peoples risk level is a present topic but has not received as much attention as it should in the planning work.

Limitations

The report was limited to investigate the risk level for three different groups of disabled people; seriously locomotion disabled, seriously visually disabled and seriously impaired hearing. Today there is about 600 000 locomotion disabled in Sweden. The number of visually

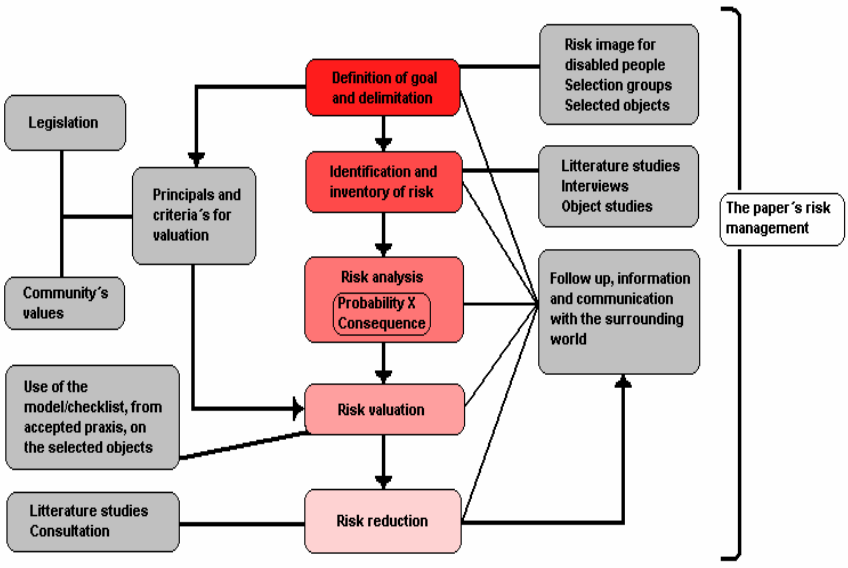
disabled people is about 175 000 and finally there are about one million people with impaired hearing. This represents 18 % of the total amount of disabled people in Sweden. The report is focusing on the 12 % of the total Swedish population who are seriously disabled.

To explain to the reader in more detail which dysfunctional disabilities the selected groups have, and which disabilities are taken in to consideration, an elucidation is made below. A seriously locomotion disabled person can stretch from walking difficulties to a person in an electric driven wheelchair. A seriously visually disabled person can vary from a person who poorly can determine colours/contrasts or being able to see only within a limited field of vision (tunnel vision) to a blind person. A person with serious impaired hearing means both reduced hearing that cannot be improved by hearing aids etc but also deafness. The categories are broad and it is obvious that within these groups a wide range if disabilities are expected. Further on the individual's own responsibility will not be studied in the report.

Method

In order to measure the level of risk to disabled people, a comparison with people with no disabilities was done. This is because public buildings are, in most cases, designed for people with no disabilities. An acceptable risk level, in this paper, is considered to be the same as satisfactory evacuation from a specified object. The focus of this paper is that every individual should have an equal opportunity to evacuate a public building. This can be achieved in several ways, ie; the person can evacuate on his own, the person can make his way to a safe area within the building or that the person can get help to reach a place of safety. A building can never achieve a hundred percent safety level in terms of protection to the persons within the building. However, there must exist an opportunity for people to evacuate the building when a so called design fire is developing. In Sweden the responsibility for this rests with the owner of the building, or with the person who has the right to use the building. The fire department has no direct responsibility for the evacuation of the building.

We started our work with the intent to find statistical evidence that disabled people are exposed to a higher risk level in public buildings, than persons with no disabilities. However, we soon found this as an impossible task due to the lack of such data. There are no available statistics for deceased, slightly/severe injured people's physical health in accidents. There are also several uncertainties such as; would a non-disabled person have managed the same situation etc. In our investigation we did not discover any similar studies within this area that we could use and develop. Therefore, the alternative that we found suitable to reach our aim with our work was a qualitative risk analysis. For this purpose we created a checklist/model with definitions for incoming variables. It was developed through a massive literature study of the limitations of the studied groups and also other literature with checklists and information concerning disabled people and evacuation. From there on, we studied different technical barriers (variables) in buildings that existed and what possibilities each studied group had to overcome these. The conclusions of this were added to the definitions of the checklist/ the model. To be able to measure the risk level and validate the model/checklist, studies/scenarios



on selected objects, five larger libraries, have been conducted. This was made separately because different variables affect differently on the selection groups. The method of risk management in the report follows the Figure below:

Model/checklist

The risk image to the studied groups can be described as the added risk a disabled person has compared to a person with no disabilities, despite the background risk (acceptabled risk in our study), in a public building. Each variable has an index value, which is graded with 0 if there is no risk increase, or with 1 if there is a risk increases. This is done separately for each studied group. Since a couple of variables do not affect all groups, these are marked with an X. Examples of higher risk level variables are: complex floor plans (fit out), stairs in the egress paths, alarm systems.

The value from the checklist/model was further calculated through a valuation between the shortage/lacking and measure variables in the building ie; sprinkler system, organizational. This generated a final index that describes the higher risk level for each group studied. With the help from the value/numbers from the index that the checklist/model generated, a risk level could be determined in a risk matrix.

A draft from the checklist/model, which was used in the report, is shown below:

Place:			
Scenario:	Type of disabilities		
Lacking/measures in the escape route	Locomotion	Visual	Hearing
Building technical			
1 Fire separations, Safe refuge [k] (Yes/No)			
2 The escape route's condition ex adapted measurement			X
3 Escape doors opening function, opening force			X
4 Threshold			X
5 Complex plan solution			
6 Contrast marketing of:			
6a Staircase	X		X
6b Escape doors	X		X
6c* Footpath	X		X
7 Noticeable marking in the footpath	X		X
8 Signs			
8a Escape plans (Yes/No)			
8b Placement of escape plans			
8c Escape signs, enough (Yes/No)			
8d Placement of escape signs			
8e Orientations plans (Yes/No)			
8f Placement of orientations plans			
9 Loose Equipment (ex chairs)			X
10 Ramps (maximal rake 1:12)			X
11 Staircase ledge/temporary escape place in the staircase [k] (Yes/No)			X
12 Hard surface (ex floor with no carpets)			X
13 Difference in level			X
* If 6c is missing this give index 0 for number 7 X No effect			
Technical			
14 Fire alarm (Yes/No)			
15 Escape alarm (visual, siren signal, talking message)			
16 Sprinkler system [k] (Yes/No)			
17 Fire roof hatch [k] (Yes/No)			
18 Fire escape buttons (Yes/No)			
19 Fire escape buttons placement			X
20 Magnet placed doors (Yes/No)			X
21 Hearing equipment or other technical equipment	X	X	
22 Fire elevator or elevator in a separate fire separation [k] (Yes/No)			X
23 Ordinary elevator + spacing in the area (Yes/No)			X
24 Distress lightening [k] (Yes/No)			
25 Fire extinguisher (Yes/No)			
Organizational			
26 Reception or something, that can give some information			
27 Fire drills, education, routines (Checklists) [k] (Yes/No)			
28 Systematic fire work (January 2005)			
Other measures/lacking			
29 Survey place, logic planning [k] (Yes/No)			
30 Access to and in the public building (Yes/No)			
[k] means that a quantitative analysis must be done			
Scenario deskription:			

In the thesis we also examined how buildings are suited for disabled people through interviewing fire safety consultants, fire safety engineers in the fire brigade, local building committee and people from the studied groups. The current legislation has been examined to investigate weather or not buildings can be designed without consideration to different groups of people. Historically it has not been the building that should adapt for people but the other way around. This may seem strange but it is the truth, even today. Buildings are more or less designed and suited for healthy individuals only.

Results and conclusions

An overarching aim with the thesis has been to apply our knowledge from the education in fire- and risk management engineers as a systematic tool in risk management, refer Figure page 2. The result of our study is that there exists no univocal answer, but an increasing complexity in buildings is generally resulting in a higher risk for disabled people. This result is drawn from the fact that the numbers of obstacles in buildings are increasing. Our analysis shows that disabled people in the studied groups have a higher level of risk, sometimes unacceptably high, and the risk image is filled with technical barriers within the buildings. The people in the studied groups are totally or partially dependent on help to be able to conduct an evacuation of the public buildings.

Some of the conclusions of this paper are; to be able to create safe buildings, even for disabled people, it requires a more defined legislation and that the building committee and the fire brigade in the municipality take their responsibility regarding supervision. In most of the examined public buildings, risk-reducing measures are required so that the risk level will be acceptable for disabled people. A general conclusion of witch measures that would reduce the risk level cannot be given since the measures are specific to the object. However, in the thesis different general suggestions are given for how to design a building so that the level of risk to disabled people does not get unacceptable high. These suggestions are divided into four groups; organisational, building technical, technical and knowledge related risk reducing measures proposals.

Finally we have, during the writing of this report, discovered many interesting areas and questions that we did not have the possibility to study any closer within the frame of the work. We hope that our thesis can be a foundation and a help to improve the situation for disabled people in today's society. We want society to become more awere of this area and increase accessibility for disabled people without reducing the safety level in public assembly buildings. This can be done by using our model/checklist.

For more information visit the webpage www.brand.lth.se and download the report "Funktionshindrades riskbild i publika lokaler - med avseende på utrymning".

Mapping of the supply chains to Malmö University Hospital in connection to risks and risk management
- a case study on four supply chains

Johan Nilsson
Mattias Sköld

Abstract

Today's hospitals in Sweden are all dependent of large networks of suppliers of medical supplies. These consist of many supply chains that are regularly exposed to both external and internal risks. One hospital affected by these risks is UMAS (Malmö University Hospital). UMAS is dependent on its supply chains to work without disruptions but it is unclear what risks they might be exposed to and how they can be managed.

This master thesis presents a mapping of these risks. Four of the hospitals´ supply chains have been analysed in a case study focusing on the structure of the supply chains, their risks and existing risk management. Based on the result of the analysis, guidelines to future risk management solutions concerning those risks are suggested.

Background

The concern regarding risks and how to handle them is continuously evolving and has gradually come to include more and more extensive areas in society. Businesses and companies are often part of larger networks, whose purposes are to deliver a satisfying product or service to the end customer. These networks range from production of raw materials to end customers and are often called supply chains. If a supply chain is to reach a satisfying result a number of objectives has to be fulfilled. The product or service has to be delivered at the right time, at the right place, in correct form and in right quantities. [1]

The supply chains are regularly exposed to a number of risks that can prevent the reaching of these goals. The risks can consist of external risks such as natural disasters or domestic disturbances. They can also consist of internal risks such as poor organisation, lack of trust and communication problems. [2] To handle these risks in an effective way the concept of SCRM (Supply Chain Risk Management) has been developed. To make SCRM work properly it requires an amount of confidence and cooperation between the different parts of the supply chain and an understanding of the chain as a whole. [3]

Today, many of the activities in the Swedish public sector are also part of supply chains. One of these activities that are depending on the supply chain to work properly is the healthcare sector, especially larger hospitals. Within the healthcare sector, objectives such as receiving supplies at the right time and place cannot only be viewed from an economic perspective. Some products, such as surgical and medical supplies, simply must always be available in order to give patients proper care. They can even make the difference between life and death. [4]

Problem discussion and purpose

This master thesis is assigned by the Supply and Facility Unit of UMAS (Malmö University Hospital), which is one of the largest hospitals in the Swedish southern health region. UMAS is a part of "Region Skåne" which is a regional public body responsible for health, medical and dental services. Every year UMAS purchases and orders medical supplies from thousands of different suppliers to a cost of several hundred million SEK. [5] The hospital is largely dependent of the proper working and effectiveness of its supply chains, and therefore disruptions are not considered to be acceptable. [6] They do however occur regularly in varying frequency and magnitude. At present day there is no existing statistical database or documentation concerning disturbances in the supply chains, which could have been a useful way of identifying risks and pointing out their main causes.

The purpose of this master thesis is therefore to map the existing risks in the supply chains of UMAS, and to suggest guidelines to future risk management solutions of that area.

Methodology

The work was conducted as a case study, following the principal rules of case study methodology. To make a proper judgement of

risks and risk management the study was focused on a fairly detailed level.
Therefore four supply chains have been selected to be studied, but on the basis of specific criteria that will make it possible to generalize the results and conclusions for all of UMAS´ supply chains to some extent. Each of the four supply chains was studied as separate cases, in order to make a cross-case comparison possible as well. Each case was studied from a structural, risk and risk management point of view, based upon interviews, observations and documents.
Furthermore they were analysed qualitatively by the use of existing theories of Supply Chain, Supply Chain Management, Logistics, Purchasing, Risk, SCRM and Risk Management.

Empirical findings and analysis

The four supply chains that were studied are all built up around the physical flow of certain medical supply products, which are all vital to the hospital activities. The four cases were named after those products, as follows:

The glove chain
The infusion chain
The implant chain
The reactant chain

Examination gloves are widely used within all hospital care activities. In the glove chain, the supply chain of examination gloves to the Emergency Clinic was studied, where they are frequently used in every day work.

In the infusion chain the supply of infusion devices to the Anaesthesia Clinic were studied. Infusion devices are, as the examination gloves, used in large quantities in many different clinical areas. These two products are manufactured by two different large international companies, but are both ordered and stockpiled at the central storage of Region Skåne, Skåneförrådet.
In the implant chain the flow of orthopaedic implants to the Orthopaedic Clinic was studied. These are high cost and high technologic products that has to be in hand at the exact right time, place in correct quality, which poses special requirements to the supply chain.
In the reactant chain, the flow of reactants for analysing blood samples was studied. The analysing process of blood is a vital support function to other clinical activities, and the reactants used require very specific qualities.
Information regarding these supply chains were collected and structured for each actor and the chains as a whole, based upon their structure, risks and risk management. The mapping of their structures after analysis resulted in maps such as the one presented in figure 1. These maps include the different actors, the physical flow of the product and the information flow between the actors.
The structure of the chain was analysed focusing on contributing risk factors. Risks identified during interviews were analysed and completed with those risks further identified by the authors. Finally the existing risk management of the chains was analysed in connection to its impact on the identified risks.

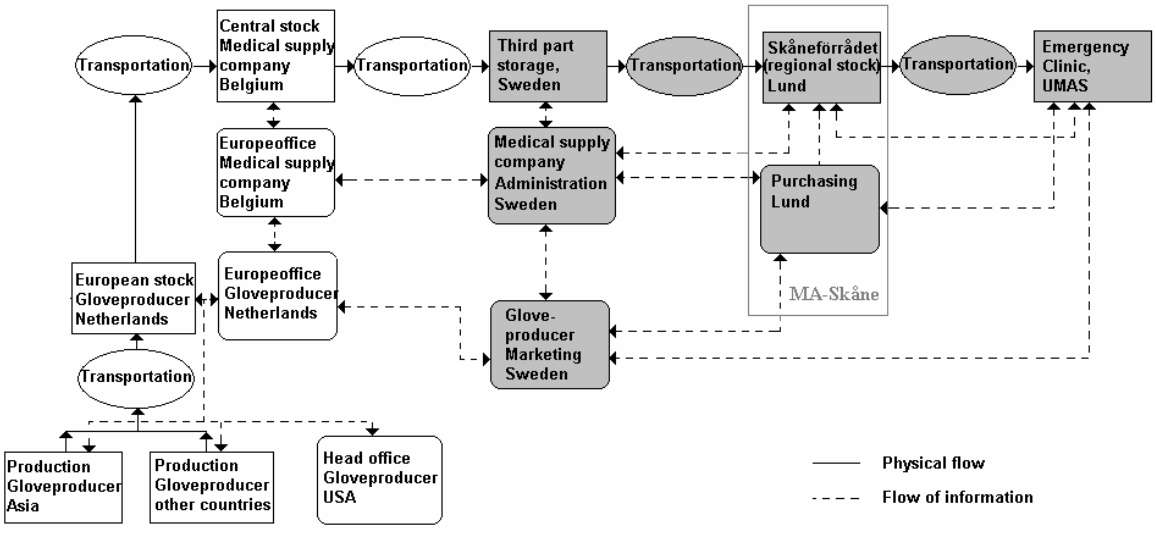


Figure1: *The figure presents the mapping of the glove chain, clarifying the different actors of the chain, the physical flow of gloves and the information flow between the actors. The grey parts represent that part of the chain especially studied in this case study*

The analysis is focused on the consequences and causes of the identified risks and the present state of risk management work. Probabilities are only estimated roughly due to the lack of historical data.

Results

The results from the analysis indicates a number of concrete risks specific to those supply chains studied. In brief, these risks consist of a too high complexity in the communication and information flows, lack of proper contractual agreements, loss of experienced staff and quality sensitivity of products. One of the most frequent occurring consequences from disruptions was an added workload to hospital staff that manages materials. This was not considered as a risk by those interviewed in the staff of e.g. the Emergency Clinic or the Orthopaedic Clinic, but more as a regular problem they had to accept in their daily work.

A report from the US Institute of Medicine suggests that such problems should not be taken lightly. It estimates that 44,000 to 98,000 Americans die each year as a result of medical errors and that the most common errors are: distractions, too much work and inexperienced staff. [x] It is possible that this could also be true within the Swedish health-care sector.

The general conclusions concerning risks in supply chains to UMAS as a whole indicate that the overall risks are not of considerable magnitude. On the other hand the existence of a number of conditions that adds to the risk exposure in the supply chains were found. In "Region Skåne", UMAS and the supplying company organisations the use of SCRM, or even risk management, risk awareness and full-scale thinking is absent. Risks in the studied supply chains are managed mainly by the extensive use of stockpiling and by relying on the few but experienced and effective key-staff working close to the physical flow of materials. Its possible that this system is trusted too much, which is why small but highly probable risks often are accepted and larger risks are met with a "it won't happen to me" mentality.

Suggestions to future risk management

The results highlight some of the most significant risks and problems concerning the supply chains of medical supplies to UMAS. These results have led to a number of suggestions to guidelines on the development of future risk management within UMAS and Region Skåne. These guidelines are not meant to give a detailed description to how specific risks can be managed, nor are they covering all areas. They are, however, meant to be a useful support in developing the risk management work and to reduce the most important risks identified in this study. The suggestions are shortly as follows:

Develop a risk management policy within Region Skåne.

Implement methods of Supply Chain Risk Management at Region Skåne´s purchasing organisation, MA-Skåne.

Establish a function at MA-Skåne to conduct continuous analyses on both local and worldwide events affecting the supply of medical materials to Region Skåne.

Set up clear and legally proper contractual agreements with all suppliers and, if possible, reduce the numbers of suppliers and develop closer relations to the ones currently used.

Develop and improve communications channels and information flows in the supply chains.

Establish a user-friendly system for reporting and documenting disruptions and incidents concerning the flow of medical supplies to UMAS.

Develop a proper system for which medical supplies to be prioritised in times of general shortage or crisis.

Establish a central materials management organisation at UMAS.

Establish a central risk management unit at UMAS.

The authors hope that this master thesis will be helpful in managing risks within the supply chains of medical materials to UMAS and Region Skåne in the future, as well as contributing to the general knowledge of risks in supply chains in connection to hospitals.

Acknowledgment

We would like to express our gratitude towards our mentors Arben Mullai, MSc and PhD student at the Division of Engineering Logistics, Lund Institute of Technology, and Hans Ohlsson, Security Manager at Malmö University Hospital.

References

[1] Paulsson, U., Nilsson, C-H. & Tryggestad K. (2004) Flödesekonomi - Supply Chain Management, Studentlitteratur, Lund, Sweden.

[2] Supply Chain Vulnerability (2002) Cranfield Center for Logistics & Transportation, Cranfield University. UK

[3] Kajüter, P. (-) Risk Management in Supply Chains. Strategy and Organisation in Supply Chains, Heidelberg, Germany.

[4] Council of Logistics Management (1991) Logistics in Service Industries. USA

[5] www.skane.se. Universitetssjukhuset MAS, Om UMAS, Ekonomi & Statistik, Årsredovisning 2003. 2004-05-13.

[6] Carlborg B. Head physician. Malmö University Hospital, Sweden. 2004-06-07

Comparison of different forms of QRA and other methods for risk assessments of process industries.

Ulf Bergstrand

Abstract

When performing a QRA you have to consider a number of accident scenarios. The chosen scenarios should represent the total risk of the assessed object. How many scenarios you choose often determines the time and resources needed to perform the QRA. The report investigates the possibility that a QRA can be performed using only a few representative scenarios. Further it presents a discussion on how these representative scenarios should be constructed.

Introduction

QRA or Quantitative Risk Assessment is a method to calculate risks from process industry installations. When performing a QRA you have to consider a number of accident scenarios. How many scenarios you choose often determines the time and resources needed to perform the QRA. The purpose of this master's thesis is to compare methods with different level of detail aiming, if possible, to find a few specific scenarios that can represent the risk of a complete installation. The purpose is also to discuss the concept of design accidents ("dimensionerande skadefall") and compare the concept to QRA.

Method

First a case study in the form of detailed QRA was performed. The QRA was applied on a heat exchange system, containing pressure condensates of propylene. The system is a part of Borealis AB's petrochemical industry in Stenungsund. The case study followed the method presented in the "Dutch Purple Book" . The case study was then analysed with the purpose to construct a few accident scenarios that could represent all the scenarios in the case study.

Results

When performing a QRA according to the Purple Book a number of "losses of containments" must be considered for all the equipment in an installation. This meant a long list of scenarios that needed to be defined for the heat exchange system. The case study resulted in calculations of 137 different accident scenarios.

In order to test if similar results in individual and group risk could be achieved with a reduced number of scenarios. Two representative scenarios were constructed. The scenarios were defined by looking at the scenarios from the case study that resulted in possible deaths of third party. Two types of scenarios resulted in possible deaths, instantaneous release of propylene from the three largest tanks and continuous release from ruptures of pipes. One instantaneous and one continuous release scenario were constructed following a statistical line of reasoning. The amounts of propylene released were calculated as an average and the frequencies by adding frequencies of single scenarios. The result of the consequence calculation of the representative scenarios was almost identical to the one in the case study.

The two representative scenarios were also compared to two scenarios representing the heat exchange system in another QRA-study, performed by experts on the processes of all the major chemical industries in Stenungsund . For this study a pipe rupture and an instantaneous release causing a BLEVE had been chosen as representative scenarios. The comparison showed that a brainstorming strategy, used in the Stenungsund study, resulted in similar types of representative scenarios. Although both representative scenarios constructed from the case study following the statistical line of reasoning had a larger amount of propylene released and a higher frequency perhaps showing that the risk of the heat exchange system could have been undervalued in the Stenungsund study. The experts could find the largest risks in the system, but they presented no detailed arguments on why the scenarios could be considered representative.

A new method was presented in the rapport showing how representative scenarios can be constructed systematically. The method was

based on the statistical line of reasoning from the analysis of the case study. The method was also influenced by AFD (Anticipatory Failure Determination). The basic concept of the method is to first choose the consequence of a representative scenario. The frequency is than estimated by considering all possible accidents that could lead to the given consequence.

Discussion

The analysis of the case study showed that QRAs can be performed whit a few well-selected scenarios. The result though is very dependent on how these scenarios are chosen. If QRA is to be used to present absolute risk measurements, as it is in for example Holland, specific guidelines on how to construct representative scenarios must be produced by the government.

The method presented in the rapport, though simple in theory, is one way to produce scenarios systematically. This makes different studies easy to compare and easy to review by the authorities.

The use of design accidents can be considered as a deterministic way of calculating risk. There is no real consideration of the probability of the accidents. The design accident should be considered more as a possible sample of an accident than a risk measurement. Companies and authorities should continue to use design accidents when planning for rescue operations and when communicating with the public.

Municipal inspection activities according to the Civil Protection Act – a proposal for a systematic approach

Stefan. Andersson
Patrik Håkansson

Abstract

The new Civil Protection Act /1/ in Sweden takes a more holistic view at accident prevention and protection than previous fire and safety regulations /2/. The level of detailed regulation has decreased and national performance objectives have been formulated instead. The main purpose of this paper is to present proposals for how municipalities, systematically and effectively, can plan and conduct inspection activities. This has been achieved by conducting literature studies and interviews with fire and rescue services and other agencies. The work has resulted in an illustrative model showing how inspections may be used as a part of the preventive activities in the municipality. The proposals are based on a holistic approach to accident (including fire) prevention, cooperation within the municipality, and effective, risk-based, inspections. Continuous evaluation, feedback and improvement are important within all areas if the municipalities are to reach the performance goals.

Introduction

The Civil Protection Act (CPA) /1/ came into force in January 2004. With the implementation of the new act the Swedish government has taken a more holistic view at accident prevention and protection than with previous fire and safety regulations /2/. They have also decreased the level of detailed regulation of the municipal work with accident prevention and protection, including fire and rescue services /7/. By doing this they wish to let the municipalities decide for themselves how to conduct their accident prevention and protection activities based on national performance objectives formulated in the Civil Protection Act /1/. This paper describes a proposal for how the municipalities, systematically, can plan and conduct their inspection activities effectively and in accordance with the Civil Protection Act /1/.

Methods

In order to be able to compile and present a suitable and practical model literature studies have been conducted. The main part of the studied literature is related to how other agencies work with, the laws which they follow and which aids they use to make their inspections effective. In order to investigate how municipalities' view the new act interviews have been conducted with 13 different fire and rescue services and three other agencies.

Fire safety management and the responsibilities of the individual

An important part of the Civil Protection Act /1/ is that it clarifies the responsibilities of the individual /7/. According to the CPA property owners and users shall to a reasonable extent keep and maintain adequate fire and life saving equipment /1/. They shall also take necessary measures in order to prevent fires and to limit the consequences of a potential fire /1/. According to the Swedish Rescue Services Agency (SRSA) property owners and users need to work systematically with fire prevention and fire safety in order to fulfil this requirement /3/. In most cases this also needs to be documented in a fire safety documentation /3/.

In addition to this owners of buildings or other sites where extra fire safety requirements are considered to be called for are required to submit a written form to the municipality specifying their, both technical and organizational fire safety measures a intervals specified by the municipality /4, 5, 6/.

With regards to fire safety management one may expect that different levels of maturity will be common. Some, for example industries who are used to work systematically with safety, already have a fire safety management programme and perhaps have integrated it with other quality /8/ and safety management activities /12/, whereas others may struggle to get it going. Common for all is however that work can be improved (according to the plan-do- check-act principle /13, 14/) which the person(s) conducting the inspections need to consider.

Due to this a principal scale for the level of maturity has been developed and is shown in figure 1. One should always strive upwards, but the continuous line represents the minimum requirements and the dashed line a recommended level for the fire safety management (FSM).

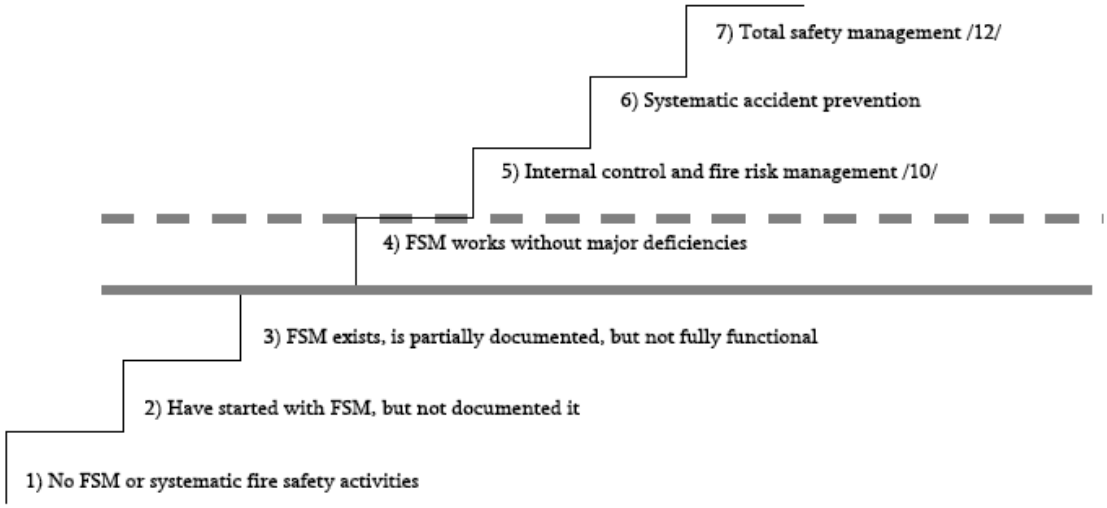


Figure 1. Levels of maturity for fire safety management and accident prevention.

It seems reasonable that complicated high-risk objects such as chemical industries and hospitals should be high up, whereas simpler objects at least should reach level 5. From a municipal viewpoint encouragement of a holistic view at accident prevention and an integration of fire risk management and other safety related activities /12/ should be in accordance with the overall intentions of the Civil Protection Act /1/.

Accident prevention responsibilites of the municipality according to the CPA

The municipalities are required to take a wholistic approach to accident prevention, including, but not limited to, fire prevention /7/. The requirements of the Civil Protection Act are formulated as performance objectives on a national level. These need to be broken down into local objectives and implemented into municipal accident prevention and protection programmes based on the local risks /7/. The municipality may choose to have separate programmes for prevention and protection or to have one complete programme /7, 14/.

The accident prevention and protection programme(s) shall, at the least, describe:

- The municipal goals for their preventive activities as well as for fire and rescue sevices
- The accident risks present in the municipality and which may require fire and/or rescue services
- How the municipal preventive activities are arranged as well as how it is planned
- The fire and rescue abilities of the municipalities as well as which resources the plan to obtain

As a basis for the programme(s) the municipality needs to identify and assess the accident risks /10, 11, 17/ in their area /7/.

Inspection requirements

In the Civil Protection Act /1/ the detailed regulations for inspections from earlier fire and safety regulations have been completely removed /7/. It is now up to the individual municipality to decide which buildings or other sites they wish to conduct inspections at /7/. The earlier system has been considered to be ineffective and with the CPA it is to become based on the local needs and hence allow for the municipal resources to be used more effectively /7, 9, 15/. Figure 2 shows the relationship between the responsibilities of the individual and inspection activities from the municipality /9, 15/.

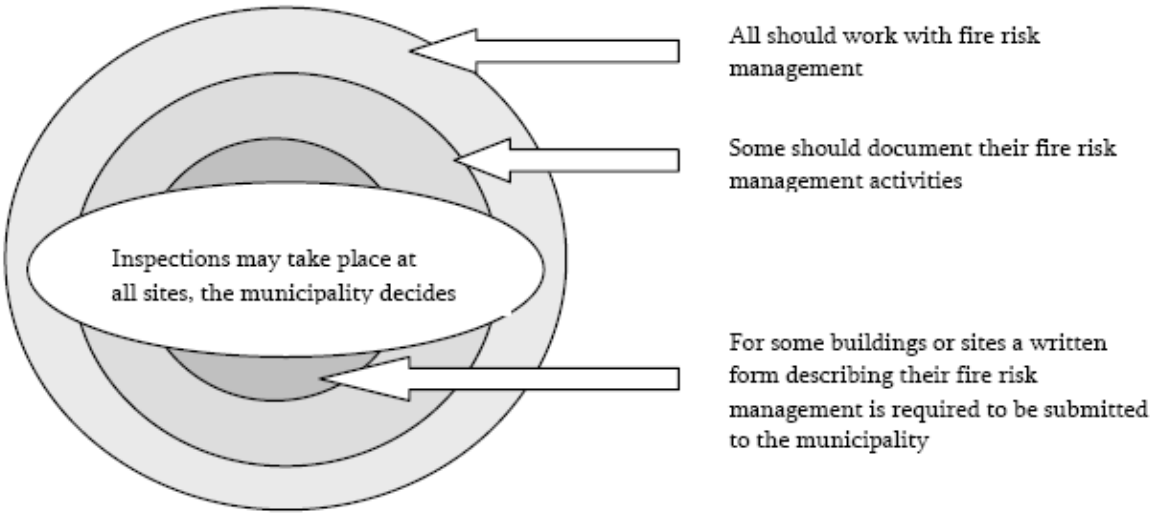


Figure 2. The relationship between individual responsibilities and inspections.

Inspections don't always need to be conducted as an on-site inspection. A review of the written forms that some owners are required to submit is also a form of inspection. One of the expectations of the CPA /1/ is that the number of on-site inspections will decrease /7, 15/.

A model for systematic planning and execution of fire safety inspections as part of the municipal work with accident prevention

The investigations have resulted in a model, which illustrates a proposal for how the municipal inspection activities principally may be organised. The model, shown in figure 3, is a proposal for how a municipality systematically can work in order to reach the performance objectives as specified in their Accident prevention and protection programme(s) /7, 14/ and in accordance with the Civil Protection Act /1/. The model also shows that inspection activities only represent parts of the municipalities' work with accident prevention.

Although the model tries to give a complete overview of the municipal work not all parts of the model are covered since the report mainly focuses on how the municipalities should plan and conduct their inspection activities with regards to the fire safety activities of property owners and users. In the model it is shown how the inspections are a part of the municipal accident prevention activities.

Figure 3. A model illustrating how the municipal inspection activities principally can be organised.

A basis for the inspections, both with regards to the planning of which buildings and sites to visit, and with regards to the planning and execution of the individual inspection are required. Here it is recommended that basis consists of accident statistics, general experience feedback, risk assessments /10, 11, 17/, the written documentation that some owners are required to submit /4, 5, 6/, experience from previous inspections, and/or tip-offs from the public.

Based on this basis, suitable strategies for preventive activities on part of the municipality are selected and an inspection plan is developed for the buildings or sites which are considered to need inspection. In the inspection plan regular, theme and/or event-based inspections may be considered. Regular inspections take place in, more or less, fixed intervals, whereas theme inspections may cover a specific area, fire hazard, type of occupancy or other definable objects. The event-based inspections are somewhat different in that they are a result of actual fires, other events and/or tip-offs from other authorities or the general public.

The dashed box in the model shows three different forms of potential cooperation /7/ between different authorities in the municipality. These forms of cooperation may result in an on-site inspection or some alternative approach. With regards to the approach at the on-site inspections, an audit /8, 10, 12/ of the fire safety management system on a suitable level for the specific object is recommended.

Continuous evaluation, feedback and improvement /13, 14/ are important within all areas of the municipal work with accident prevention if the municipalities are to reach the performance goals specified in their accident prevention and protection programmes. The loop from Evaluation, feedback and quality control /8/ to the Accident Prevention and Protection programme /14/, symbolize a series of smaller loops (not shown in the model), meaning that evaluation, feedback and improvements should take place on all levels. One important conclusion is therefore that quality control is what ties the municipal accident prevention and protection activities together and makes it performance-oriented. What is not shown in the model, however, is the need for competent personnel in order to be able to work in accordance with the performance-based principles of the Civil Protection Act /1, 16/.

The purpose of the proposals is to give the municipalities ideas that may be implemented in their preventive activities. The proposals are mainly based on a holistic approach, both with regards to the perspective that the entire municipality should be involved and utilized in the accident prevention activities, and with regards to the individual inspection of fire safety in buildings or other sites.

References

1. SFS 2003:778, Lag om skydd mot olyckor (in Swedish only).
2. SFS 1986:1102, Räddningstjänstlag (in Swedish only).
3. SRVFS 2004:3, SRV:s allmänna råd och kommentarer om systematiskt brandskyddsarbete (in Swedish only).
4. SRVFS 2003:10, SRV:s föreskrifter om skriftlig redogörelse för brandskyddet (in Swedish only).
5. SFS 2003:789, Förordning om skydd mot olyckor (in Swedish only).
6. SRVFS 2004:4, SRV:s allmänna råd och kommentarer om skriftlig redogörelse för brandskyddet (in Swedish only).
7. Proposition 2002/03:119, Reformerad räddningstjänstlagstiftning (in Swedish only).
8. ISO 9000:2000, Quality management systems - Fundamentals and vocabulary, International Organization for Standardization
9. Aktuellt från Räddningsverket – Nr 2 februari 2004 (in Swedish only).
10. Guide 73:2002, Risk Management – Vocabulary – Guidelines for use in standards, International Standards Organization (ISO/IEC), 2002
11. IEC 60300-3-9, Dependability management - Part 3: Application guide - Section 9: Risk analysis of technological systems, International Electro technical Commission, 1995
12. Administrativ SHM-revision - Riskhantering 1, Kemikontoret, 1996 (in Swedish only).
13. Deming, W.E., The New Economics: for industry, government, education, MIT CAES, Cambridge, USA, 1994
14. Utkast till idéhandbok, version 1, Processen - att arbeta med handlingsprogram för skydd mot olyckor, Statens Räddningsverk, Karlstad, 2004 (in Swedish only).
15. Presentationsmaterial vid seminarium om lagen om skydd mot olyckor, Statens Räddningsverk, Revinge, 2004-03-17 (in Swedish only).
16. Fredholm, Lars, Metodutveckling brandsyn, Statens Räddningsverk, Karlstad, 1996 (in Swedish only).
17. Davidsson, Göran m.fl. Värdering av risk, Statens Räddningsverk, Karlstad, 1997 (in Swedish only).

Appendix A

Master of Science in Risk Management and Safety Engineering
A Programme Description

LUND UNIVERSITY

The Risk Management and Safety Engineering Programme
Johan Lundin

Master of Science in Risk Management and Safety Engineering at Lund University, Sweden

Johan Lundin & Robert Jönsson
The Risk Management and Safety Engineering Programme
Dept. of Fire Safety Engineering, Lund University
P.O. Box 118, SE-221 00 Lund, Sweden
Phone: +46 46 222 7360, Fax: +46 46 222 4612
E-mail: johan.lundin@brand.lth.se, robert.jonsson@brand.lth.se

Abstract

The M.Sc. at Lund University is based on a multi-disciplinary approach to risk management and has the objective of providing industry and the public sector with risk managers able to be professionals in the following areas of risk:

- Safety risks
- Health risks
- Ecological/environmental risk

This paper gives a brief presentation of the structure and contents of the programme.

Introduction

Risk analysis and risk management are growing in importance. The reasons for this are the rapid changes in society and social life, economic forces, technological development, and new types of production systems and organizational structures. Information technology ties units together in large complex and interdependent systems with short time constants, allowing little or no time for the correction of mistakes or for counteracting effects due to unforeseen circumstances. Boundaries between authorities are often vague. This is often also the case in company subsystems, and all the way up to the global scale. The concentration of people, dangerous chemicals, energy, information and other values is increasing, which may considerably increase the effects of accidents. There are strong forces driving humanity and nature, as well as organizations and individuals, toward a world of "produced uncertainty and organized irresponsibility". Counter-forces have to be found and used as soon as possible.

It will rarely be possible to eliminate risks entirely. All life involves some risk, and any innovation brings risk as well as reward – so the priority must be to manage risks better. We need to do more to anticipate risks, so that there are fewer unnecessary and costly crises, like BSE or failed IT contracts, and to ensure that risk management is an integral part of all delivery plans. But we also need to be sure that innovations are not blocked by red tape and risk aversion, and that there is a proper balance between the responsibilities of government and the responsibilities of the individual. Risk managers will always have to make decisions under uncertainty with limited resources at hand.

Programme objectives

To meet up to the present and future demands of risk management, Lund University started a two-year engineering programme leading to a Master of Science in Risk Management and Safety Engineering in 2001. The programme places great emphasis on acquiring knowledge on the different threats and risks present in society, during both normal activities and accidents. The programme should, in particular, offer students the conditions to learn and apply risk analysis as a systematic tool:

- To identify and assess risks.
- To implement measures to reduce risks with the objective of preventing, or at least limiting, injury to humans, and damage to the environment or property.
- Based on the objectives of organizations and the requirements of society, to formulate and work with management systems, especially in the areas of safety, health and the environment so as to establish a low level of risk with regard to finance and sustainable development.

The main focus, with emphasis on safety, health and the environment, will be on accidents defined as undesirable incidents having an adverse effect on people, the environment, equipment, property and business. These incidents are usually of short duration, are unintentional, and do not form part of the normal function of the system.

Other effects on health and the environment will also be considered, where the exposure is long-term in character and is a result of the normal function of a system, or of a normal lifestyle.

In particular, engineering education should provide the basis for the application of risk analysis as a systematic work process according to Figure 1 in the following areas:

- Systematic collection and evaluation of risks and the ability to initiate measures to reduce risks in order to avoid injury to humans and damage to the environment or to property.

- To create processes, products, and working environments with consideration for the requirements of organizations and society regarding safety, the environment, health, conservation of resources, and economy.

The education should also increase the depth and breadth of knowledge, and create the capability of communicating and collaborating with many different categories of technical and

non-technical individuals, as well as being able to work in risk management on the local, regional, national and international scale.

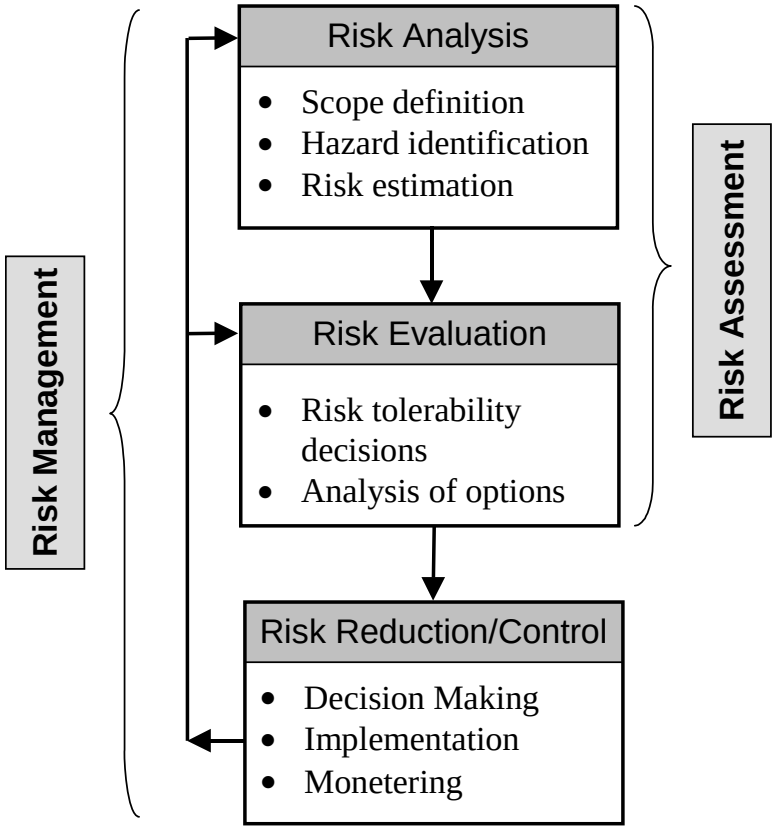


Figure 1. Flow chart for risk management [2, 3].

Programme structure and content

The programme consists of compulsory courses, elective courses, and senior thesis (M.Sc. dissertations), see Figure 2. The compulsory course block covers 40 credits (one year full-time studies). This block contains basic courses in the area of risk management, which provide the basis for risk analysis, risk assessment and the development of risk-reducing measures. The compulsory block starts with courses in basic methods and techniques in both business administration and engineering. The basic knowledge obtained is then employed in the next set of courses, which are more applied. The forms of teaching are both traditional, with lectures, and project based.

In the end of the first year the students can start to extend and specialize their training knowledge through elective courses and a senior thesis, to a large extent according to their own interests. Their choice of elective courses should lead to both a broadening and deepening of their knowledge, such that they are capable of taking responsibility for the development of new techniques and methods.

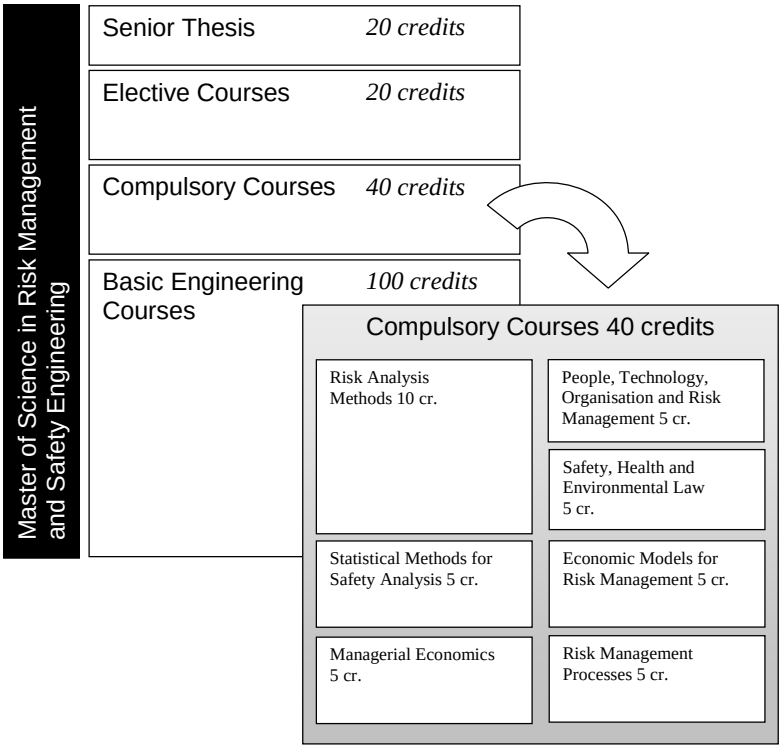


Figure 2. Content of the Master of Science Programme in Risk Management and Safety Engineering.

The programme is largely based on students themselves selecting the elective courses in order to create a personal profile and specializing in one of the areas of safety, health and the environment. This is based on trends in society towards a growing importance of individual responsibility in terms of education, especially regarding flexibility and choice. It is also important to recognize the different levels of risk management maturity in different engineering disciplines. The approaches taken in different industry sectors are far from harmonized [4]. It is impossible to cover all aspects of risk management and safety engineering in a master's programme, but it should provide the basis from which an overall view of how risks affect organizations can be applied. Facility in assimilating new knowledge is therefore an important quality, as well as being able to communicate this knowledge to others.

Description of optional courses

Risk Analysis Methods
(Swedish credits: 10, ECTS credits: 15)

Upon completion of the course, the student should be able to provide support in risk analysis for groups working with risk management. In the field of safety, the student should be able to carry out a quantitative risk analysis for an industrial plant. In the fields of health and environment, it should be possible for the student to perform a danger analysis. The analysis methods with which the student should be familiar range from qualitative and semi-quantitative to quantitative risk analysis methods. The management of uncertainty plays a central role and is an important part of the course. Methods for the quality assurance of models and input data with regard to analysis will be dealt with.

Statistical Methods for Safety Analysis
(Swedish credits: 5, ECTS credits: 7.5)

The course aims to give the necessary knowledge of statistical methods for safety analysis and to apply the methods to some scenarios. The following content forms the base of the course: statistical tools for risk assessment, bayes' theory, Weibull distribution and other extreme value distributions, event intensities and the Poisson process, statistical correlation and Monte Carlo-simulation, use of means, standard deviations and quantiles for risk assessment, risk computations, safety index and extrapolation of small risks.

Managerial Economics, Basic Course
(Swedish credits: 5, ECTS credits: 7.5)

The purpose of the course is to give basic knowledge in Managerial economics. In the course the following issues are addressed: basic concepts, models and management control system, product costing and capital budgeting techniques, profitability assessment, understanding of a company's annual financial report and accounting analysis, the external accounting systems of industrial companies and marketing.

People, Technology, Organization and Risk Management
(Swedish credits: 5, ECTS credits: 7.5)

The course imparts knowledge about the role and function of people and organizations in man-technology systems especially focusing on safety taking competitiveness and working life quality into consideration. After the course the student should be acquainted with the basics of human errors. Furthermore the student should have the foundations for design and assessment of man-technology systems, products and organizations for safety from an MTO-perspective (MTO = Man, Technology and Organization). The student should also be acquainted with the basics of risk management systems from an MTO-perspective.

In the course the following issues are addressed: Human factors and ergonomics, their role in risk management. The Rasmussen model and a holistic view of risk management. The GEM-model. Perception. Cognition. Memory. Learning. Human errors - taxonomy and theories, latent errors, safety barriers, situational factors, Rasmussen's SRK-model. Stress, arousal, Yerkes Dodson's law (inverted U), psycho-social and physical factors and risk. Decision making including dynamic decision making. Team and team training. The remedies: selection, training and good man-technology systems. Product development and interface design for safety, usability tests, standards and guidelines, scenarios, function and task analysis, heuristic analysis, expert assessments, 'walk-throughs'. Analysis of some major accidents with a focus on MTO causes. MTO-risks in some branches. Risk management systems from an MTO perspective. Safety Culture. Human and organizational factors in risk analysis.

Safety, Health and Environmental Law
(Swedish credits: 5, ECTS credits: 7.5)

Issues regarding the handling of risks in the legal perspective are full of nuances and very complex. The various areas are often covered by detailed regulations, which are updated concurrently with developments. Special emphasis will therefore be placed on ensuring that students are familiar with the legal system concerning safety, health and the environment. The course covers learning to find and apply current regulations, as well as obtaining a more general understanding of the system, which is important when solving practical problems. Some international, mainly EU, matters will be dealt with

Economic Models for Risk Management
(Swedish credits: 5, ECTS credits: 7.5)

The aim of the course is to provide knowledge in economic theory and its applications and to lay a foundation for the use of economic models in connection with risk and uncertainty. The main areas of application are the calculation of investments, life cycle cost analysis (LCC) and problems associated with decisions that have to be made in situations of risk and uncertainty, for example, insurance.

The course includes the following: risk management in technical and economic systems (from both industrial and societal perspectives), risk reduction, risk management in economic documentation, efficient risk management, diversification/hedging/insurance, risk aversion, problems associated with principal-agent relations, and economic evaluation of risks in investment calculations and national economic analysis.

Risk Management Processes
(Swedish credits: 5, ECTS credits: 7.5)

The aim of the course is to bring together and integrate elements in other courses. The general goal is to provide knowledge on the methods and techniques used in the risk management process. Upon completion of the course, the student will also be familiar with the basics of project management, especially risk management projects. This knowledge will be applied to a project, which forms part of the course. The course will bring together risk analysis, risk evaluation and the reduction/control of risks to risk management, i.e. the student will practice his or her ability to make decisions, in the project, based on the analysis and evaluation of risks. The aim is also to create conditions for the reduction of loss, damage and injury, and interruptions in operations in an optimal way for the organization (based on the analysis and evaluation of risks), and to:

- transform uncertainty regarding undesirable events into more predictable, controllable and budgetable conditions,
- prepare an organization for that which is unlikely, but possible.

The knowledge gained during this course will facilitate communication with other parts of a company or organization, and considerable emphasis will be placed on risk communication, i.e. the communication of risk management to the public.

Examples of elective courses

Applied Process Industry Safety
(Swedish credits: 5, ECTS credits: 7.5)

The magnitude of the risks in a processing plant is determined, to a large extent, during the planning and design stages. It is therefore of great importance that those involved in risk management (in areas including safety, health and the environment) in the process industry have knowledge concerning the basic technical issues. The goal is that students will gain basic knowledge and sufficient knowledge regarding the important aspects of ensuring the safety of a processing plant, in order to be able to apply risk management methods included in the Risk Management Programme. This course is also suitable for students who have not studied pure process engineering.

Emergency Management
(Swedish credits: 5, ECTS credits: 7.5)

The course is intended for those who have, or expect to have, leading positions in a) the management of accidents and/or b) planning for preparedness in the case of accidents. The actual goals are:

- to provide insight into the effects of crises and accidents on socio-technical systems,
- to provide insight into the problems encountered in managing socio-technical systems that have been affected by accidents,
- to provide insight into strategies employed in managing various types of accidents in socio-technical systems,
- to provide insight into how a state of preparedness can be developed for the management of accidents in socio-technical systems.

Risk Based Land Use Planning
(Swedish credits: 5, ECTS credits: 7.5)

The aim is to provide the student with the basic knowledge required so that he or she can take part in planning at an early stage, to ensure that risk analysis is included in a strategic phase of land use planning (urban planning). To acquire knowledge on the basics of planning methodology: description of objectives, inventories, analysis and the development of a proposal. To put this knowledge into practice in outline planning and detailed planning. Parts of the course will also be dealt with on a more detailed level. Parallel with the land use planning part of the course, another part of the course aims to provide knowledge on how various kinds of risks can be dealt with in land use planning, based on risk analysis. This part of the course provides insight into the use of legislation as a means of ensuring that risks are considered in land use planning. The student will be expected to understand the points of view of various central, regional and local authorities regarding ”risk consideration in land use planning”. The course also includes lectures, seminars and literature that elucidate problems associated with the vulnerability of society and consideration of contingency planning in land use planning.

Consequence Analysis
(Swedish credits: 5, ECTS credits: 7.5)

Upon completion of the course, the students should:

- have good knowledge of the properties of dangerous chemicals,
- be conversant with the theory behind rescue operations following accidents involving chemicals,
- be able to carry out consequence evaluation following the accidental release of chemicals,
- be able to use GIS to plan operations following the accidental release of gas or liquids.

Fire Chemistry and Explosions
(Swedish credits: 10, ECTS credits: 15)

Upon completion of the course, students will: be able to assess the risk of fire where the fuel consists of gases, liquids or solids; be able to describe how the fire will develop regarding the heat generated, radiation, smoke and poisonous gases; be able to assess the risk of personal injury; have an understanding of the basic processes of heat transfer and be able to apply this knowledge in practice in fire physics; have gained knowledge on the properties of materials in relation to fire; be able to determine the causes of fires.

Senior Thesis
(Swedish credits: 20, ECTS credits: 30)

The senior thesis is intended to demonstrate the student's ability to apply knowledge acquired during the course of studies, and that the student is able to carry out a specific task in an independent manner.

The thesis consists of work corresponding to twenty weeks of full-time studies, 20 credits and should be carried out as the final part of the educational programme.

The work may be undertaken at the University, at an industrial site, in a municipality, or at a research institute in Sweden or abroad. However, a faculty member from the University must always act as the supervisor. The project work may be theoretical and/or experimental depending on the student's background and interests. The project work is summarized into a written thesis and presented at a seminar and published in full text on the programme web site.

Experiences during a three year period

The experience so far, when almost 40 students have graduated and 70 students are in the programme is that senior thesis is both well received by practitioners and also of high scientific standard. Theses have already been presented at international conferences [5] and new topics for master's thesis are continuously received from the industry and the public sector.

There is strong competition for access to the programme. The group of applicants consists of highly motivated students with good examination results, which creates excellent conditions for successful studies at University.

Students with different engineering backgrounds (bachelor degrees), are educated together, but with the possibility of specializing and extending themselves in a range of different areas, which results in a very interesting and varied range of competences and interests.

So far, students are employed even before graduating and the demand for well educated risk management professionals seems strong both in industry and the public sector. Figure 3 shows in what sectors the graduating students have started to work.

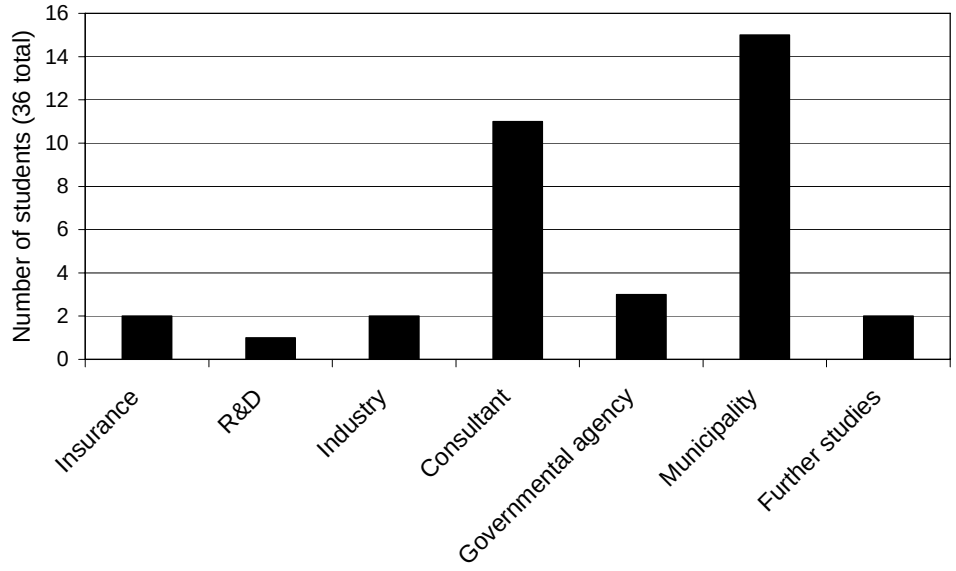


Figure 3. Sectors where the first graduate students have been employed.

Research umbrella

The multi-disciplinary knowledge base at Lund University has been a necessary condition for the implementation of the programme. Lund University is currently undertaking a special effort in the area of risk research. A multi-disciplinary risk research centre, LUCRAM (Lund University Centre for Risk Analysis and Management) has been established.

Through a network of researchers at several different universities and organizations in the Öresund region, LUCRAM is intended to contribute to developing and disseminating knowledge of research and education in risk analysis and management. Nevertheless, to be able to maintain a high quality master's programme international collaboration and benchmarking is necessary.

References

[1] Magnusson, S. E. et al., Co-operative Nordic Risk Research, Lucram report 1001, LUCRAM, Lund University, Lund, 1999.

[2] International Standard 300-3-9, International Electrotechnical Comission (IEC), Genéve, 1995.

[3] International Standard Organization (ISO/IEC), Guide 73, Risk Management – Vocabulary – Guidelines for use in standards, Genéve, 2002.

[4] Kirchsteiger, C. EC–JRC International Workshop on ‘‘Promotion of Technical Harmonization on Risk-based Decision Making,’’ Guideline for Invited Experts. Section 2.1, Revision 6, 2000.

[5] Ingvarsson, J. & Roos, A. Methods for Risk and Vulnerability Analysis, Presented at the First World Congress on Risk, Brussels 24-26 June 2003.

Appendix B – Authors Index