RISK ASSESSMENT OF THE EMERGENCY PLAN APPLICATION

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Abstract: As common practice in safety management procedure, risk assessment is performed as part of establishing procedure of safety management system. Potential risks are identified, assessed and proper preventative measures established. After the occurrence of accidental event, emergency plans offer relief and recovery measures based on risks assessed prior to accidental event. Further risk assessment of emergency plan application has to be done on site due to changed circumstances and availability of assets and manpower.
In cases of serious hazards to people and environment established risk assessment matrix is to be viewed from different standpoint making some risks acceptable in extreme situations.
It is the intention of this paper to explain on site risk assessment and selection of applicable emergency plan sections to reduce level of risk and the scale od damage while performing recovery procedure.

Introduction

After the occurrence of accidental event which can cause damage to human life, assets, environment and affect company's reputation and continuity of business, recovery measures have to be undertaken according to already prepared emergency plan or emergency plan created in real time on site.

Emergency plans are based on possible scenarios emerging from the occurrence of accidental event and the post accident state of the affected system. Unfortunately it is known that most accidents do not happen according to ideal scenarios and in the majority of cases there is a discrepancy between real on site situation and the emergency plan which should provide applicable procedures for the recovery of system after the occurrence of the accidental event.

Depending on the nature of accident and the dynamics of consequences development it is necessary to approach accidents more carefully and studiously. Using bow tie diagram as a timeline describing the development of accidental event and emerging consequences it is possible to determine the moment in which risk assessment of available recovery measures can be performed. Risk of the emergency plan application can be assessed using well known techniques which are to be selected depending on the available resources.

1. Assessing the risk of the emergency plan application

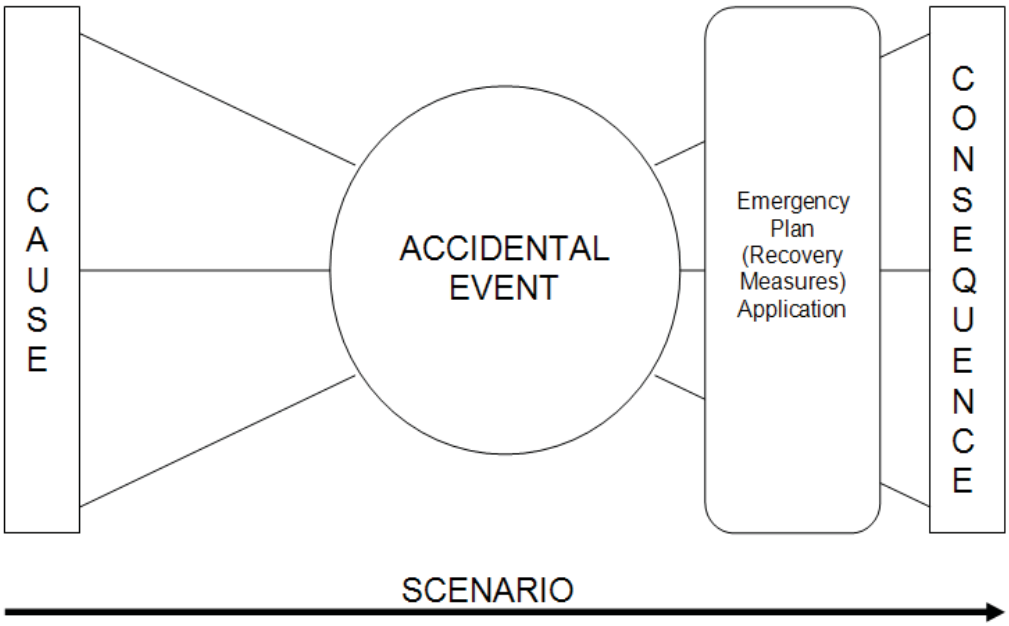
First step after the occurrence of accidental event is assessing the condition of the system. As system is an integrated set of constituent pieces that are combined in an operational or support environment to accomplish a defined objective (U.S. Department of Transportation Federal

Aviation Administration Air Traffic Organization, Safety Services, 2006), each affected system component has to be inspected and assessed as well as its influence on system as a whole.

Analysis of the system in post accident condition depends on sustainability of the system in immediate post accident period, nature of accident and the rate of development of consequences. If the accident was expected and its probability established in the initial risk assessment then there should exist an emergency plan consisting of recovery procedures which aim to prevent accident consequences using predetermined resources. In case there is available time for analysis and evaluation of recovery measures proposed by the emergency plan, risk assessment of the application of those measures and their alternatives should be performed on site. Otherwise, recovery and relief measures proposed by the plan are to be applied in consecutive order as suggested in the plan taking into account decision makers knowledge, experience and logic.

Risk assessment of the emergency plan application must include data on post accident system condition with emphasis on system components essential for the execution of recovery measures, available means for performing recovery measures (assets, manpower, availability of external assistance etc.) and time frame set for their application.

Figure 1. Bow Tie diagram



Emergency plan risk assessment should include all sections of the emergency plan applicable to the situation caused by the accidental event. Usually emergency plans propose different measures to deal with different aspects of the system: human life, environment, assets and business continuity. It is a very rare situation, except in very isolated cases, that measures proposed by various sections of emergency plan deal with the recovery of all aspects of the system so it is obvious that some sacrifices have to be made according to predefined priorities.

When assessing the risk of recovery measures application proposed by the emergency plan special attention should be given to the choice of a suitable risk assessment method. In any case, risk assessment is supposed to provide clear results in qualitative or quantitative form in order to support decision making.

2. Suitable risk assessment methods

According to majority of authors risk is a combination of the probability of the danger occurrence and the damages it could cause while the level of safety is complementary to the level of risk.

Any risk study involves three major elements: risk analysis, risk assessment and risk management. Risk analysis deals with the identification of dangers, estimation of their frequencies and their consequences, without explaining their explicit significance. Risk assessment procedure is based on previously completed risk analysis aiming at deciding whether the tolerable risk has been reached. Risk management is a procedure of selecting the appropriate measures to reduce the risk to a tolerable level and integrate them in the management procedure of regular activities (Trbojevic, 2001).

Selection of the risk assessment approach has to be carefully done and significant factors that can help choose this approach are to be considered. The quantity and quality of the used information determines the degree of the approach flexibility. Low level of information limits the choice to rough and poor approaches. Use of traditional methods is undesirable at a certain level, particularly if the potential of a major danger is significant. In general, the danger identification is qualitative and based on an expert judgment. It should be creative, structured, well defined, and benefit from the experience of accidents.

Different types of approaches can be used to assess the risk: they can be qualitative, semi - quantitative or quantitative. Generally, the qualitative approaches are easier to apply. They require fewer resources and fewer skills. However, they provide less meaningful results. On the other hand, the quantitative approaches require more resources and skills, but provide more detailed and comprehensive results. Semi-quantitative approaches are situated between both of these extremes. Choice of the suitable risk assessment method depends on the complexity of the system and dynamics of events caused by the accident. In emergency circumstances it is preferable to avoid complex methods and aim at simplification and clarity but still preserve certain level of thoroughness.

Most commonly used qualitative risk assessment methods are AMDEC and Risk Matrix method.
The AMDEC (Analyse des Modes de Défaillance, de Leurs Effets et de Leur Criticité (French for FMECA- Failure Mode and Effect Analysis)) is a risk analysis method operating on the whole system. It is static, based on an inductive reasoning (causes-consequences) to study the causes, the effects of failures and their criticality. It consists in determining the significance of every failure mode according to its influence on the system behavior, enabling to assess the impact of the failures on the reliability of the system safety (EURAMP, 2006). Despite its simplicity it is not adapted to real time processes and it is more suitable as a method for preliminary risk assessment of the system that can be used to build safety management system.

The approach of the risk matrices seems to be the most commonly used technique to assess the risk because of its simplicity and almost universal applicability. Several types of matrices are used and the most common matrix is the one with categories of probabilities and very simply interpretable consequences. It uses four types of consequences (damages) concerning the human life, the goods, the environment and the reputation. The difficulty of dealing with new dangers and heterogeneous dangers limits the use of this method.

The dangers are identified; their frequencies and their consequences are assessed. The frequencies and the severity of the consequences are distributed on a scale, typically with 3 to 6 levels. The frequencies can be: very improbable, improbable, probable and frequent. The

severity can be: negligible, little significant, significant and catastrophic. The risk is assessed according to a matrix of type shown in figure 2, the level of which can be distributed on a scale with 2 to 6 levels, and the title of these levels can be different (e.g. acceptable or tolerable) according to the used standard. But there should be at least one level called unacceptable or intolerable, that is incompatible with the safety concept and the system operation (EURAMP, 2006).

Figure 2. Risk Assessment Matrix (Zuijderduijn , 1999)

Degree	Event consequences				Occurrence Probability →				
	On people	On the assets	On the environment	On the reputation	Not probable	Slightly probable	Probable	Very probable	Extremely probable
0	No injuries	No damage	No effect	No significance					
1	Light injuries	Minimal damage	Minimal effect	Minimal significance					
2	Minor injuries	Minor damage	Minor effect	Minor significance					
3	Major injuries	Local damage	Local effect	Limited significance					
4	Single casualty	Severe damage	Serious effect	National significance					
5	Multiple casualties	Total loss	Massive effect	International significance					

Acceptable risk | Non desirable risk | Unacceptable risk

The risk matrix methods show some weakness points:

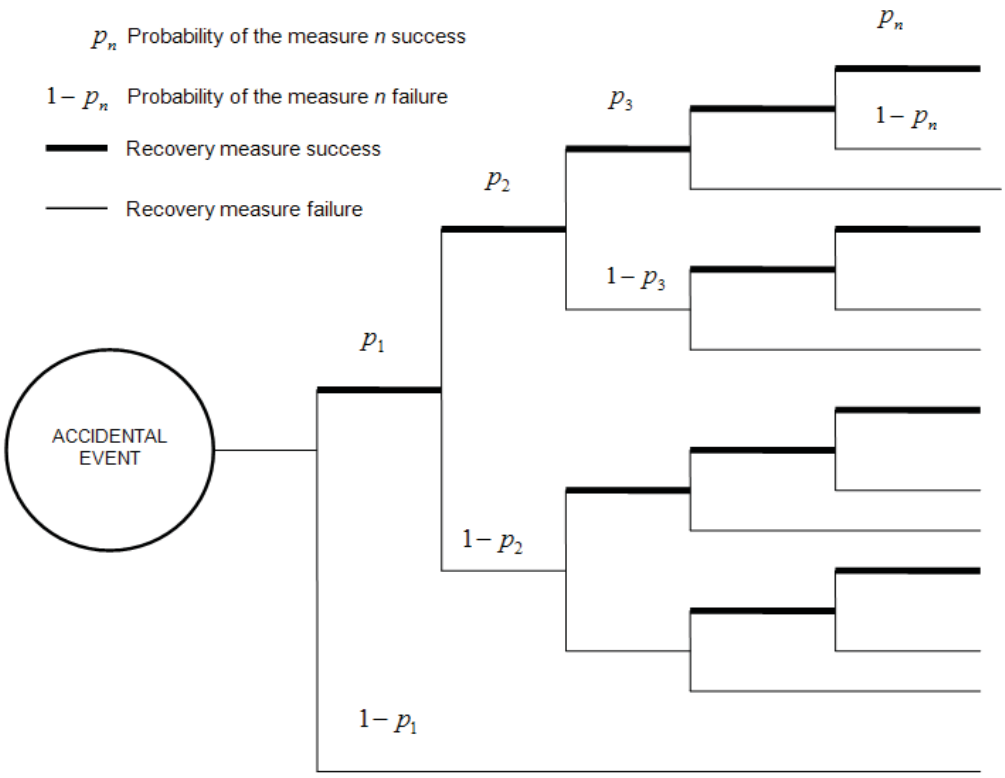
1. Several coherent judgments are necessary to estimate the accident probability and their consequences. It is sometimes difficult to choose the correct consequence for a risk category.
2. The risk matrix addresses only one danger at a time and tends to underestimate the total risk on which the decision should be based concerning the risk.
3. The lack of standardization can lead to confusion.
4. The difficulty to process new dangers.
5. Some matrixes use quantified definitions of the frequencies and consequences. The risk can be obtained adding the values of its frequency and of its consequences. It doesn't constitute quantification and the method remains qualitative (EURAMP, 2006).

Semi-quantitative methods are more accurate than risk matrices. They use quantitative techniques of risk analysis without giving quantified results. The most well known methods are Fault Tree Analysis, Event Tree Analysis and Bow Tie Analysis. Since Bow Tie Analysis is an arborescent type method composed of an event tree and a failure tree where the connecting point of the bow tie represents accidental event, in case of emergency plan application it is not suitable for an in-depth risk analysis and assessment, but provides efficient timeline presentation. Fault Tree Analysis starts from the undesirable final event and through a tree constructed by combinations of intermediate events leads to initial event that caused or could cause accidental event.

On the other hand, Event Tree Analysis covers the part of timeline after the occurrence of accidental event that triggers emergency plan application. It aims at determining the resulting events from an initiator event and provides the estimation of the system drift. The general approach consists in:

1. defining an initial event (accidental event)
2. defining all of the corresponding safety measures (applicable recovery measures)
3. building the tree
4. describing the sequence of the events (EURAMP, 2006)

Figure 3. Event Tree Analysis adapted to recovery measures application risk assessment



In case of recovery measures risk assessment the tree is constructed on the basis of the accidental event. The quantitative operation of the event three method aims at estimating the occurrence probability of the final consequence from the intermediary events generated by the accidental event where recovery measures considered for application are represented as intermediary events included in the tree. It enables to quantify the risk, attributing a level of probability to every included event (recovery measure). This approach enables to rank the various possible scenarios to focus the effort on the most probable one. However, it is complicated and difficult to apply on large systems (EURAMP, 2006), but remains a very powerful method suitable for assessing risk of recovery measures application.

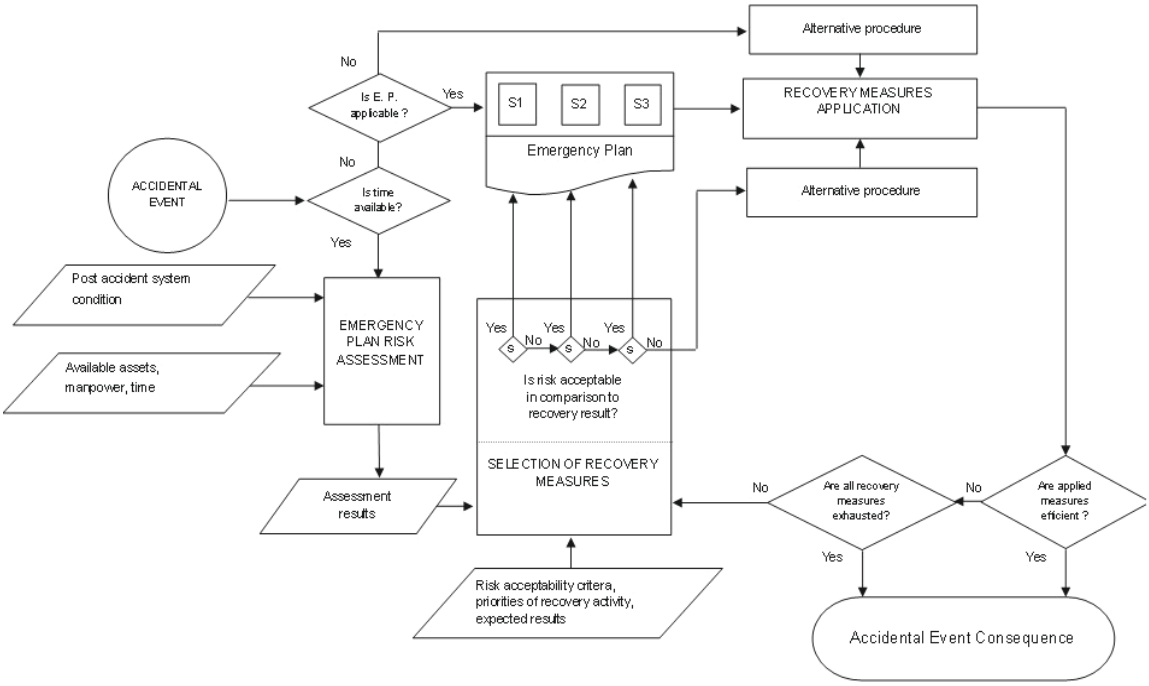
The quantitative risk analysis (QRA) is one of the most sophisticated techniques of risk assessment. It provides an explicit understanding of all the hypotheses and factors contributing to the accident. In general, these methods use techniques based on statistical analyses of the background data in order to estimate the failure cases. These methods are known as analysis methods of frequencies. The estimation of the frequencies are performed with techniques such as: frequencies analysis of the accident backgrounds, Fault tree quantitative analysis, Event tree quantitative analysis, Bayesian analysis, Consequences methods, Human reliability analysis etc. Application of these methods in emergency circumstances is limited by the resources and the available time. However, it is possible to use already existing models adapted to systems post accident condition to perform analysis by simulation in order to predict the effect of applied recovery measures (Faber, 2001).

In cases of frequent and non significant risks or in cases where there are no other means, it would be more appropriate to perform an estimation of the frequency based on a personal experience using assessment through judgment.

3. Selection of recovery measures

Risk assessment process must provide comparable results of risk levels attached to each applicable recovery measure proposed by the plan or created ad hoc. Those results are to be compared with predefined risk matrix to establish risk acceptability.
Before selecting recovery measures it is essential to determine the aim of recovery activities and establish an order in which it will be possible to apply selected recovery measures taking into account post accident condition of the system.
Recovery measures which can be applied with acceptable risk have to be compared against the cost of their execution and the expected recovery result. It is obvious that those recovery measures that satisfy defined priorities with acceptable risk of execution and favourable input/output ratio will have priority in the selection order (process).

Figure 4. Flowchart of emergency plan risk assessment process triggered by the accidental event



It is understandable that priorities of recovery activities will be preservation of human life, environment, assets and protecting business continuity. In some cases business continuity will be ranked higher on the list of priorities to be achieved according to the policy and aims of the affected system.

After the appropriate measures have been selected on the basis of assessed risk and defined priorities, they should be executed according to the procedure described in relevant emergency plan section, or in case all recovery measures proposed by the plan were rejected, according to the alternative procedure created on site.

Execution of recovery measures has to be monitored and managed in real time until achieveing satisfying the level of safety. In case undertaken measures are not effective, additional recovery measures have to be activated until all measures selected during

assessment process are exhausted. If circumstances in which recovery measures are being executed are changing rapidly, new assessment of system condition has to be performed.

If applied measures are efficient and the condition of the system is satisfying, recovery process is terminated. Accidental event will still leave its consequences on the system, but at an acceptable level (spent assets, time loss etc.).

Conclusions

Risk of the emergency plan application can be assessed by testing recovery measures probability of success and failure using the technique of Event Tree Analysis. The using of this method is limited by its quantitative component and availiability of resources. Risk Assessment Matrix can be used to define acceptability of risk and in some cases to assess risk, but it depends on the personal experience of the assessor.

Selection of recovery measures to be applied is influenced by aimed condition of the system, ratio of engaged assets and the expected result of application and established level of involved risk. It is obvious that those measures which can be applied with acceptable risk and can provide maximal recovery result with minimal use of assets will be selected in recovery procedure.

References

1. Ernhofer, Oliver (Editor); Habib Haj-Salem; Ramananjaona, Cristophe; Kates, Ron (2006): Safety Critical Issues, EURAMP - European Ramp Metering Project http://www.napier.ac.uk/

2. Faber, M. H. (2001): Lecture Notes on Risk and Safety in Civil Engineering, Swiss Federal Institute of Technology, Zurich, Switzerland, www.ibk.ethz.ch/fa/about/Info150ETH_EN

3. Trbojevic, Vladimir M.(2001): Linking Risk Assessment of Marine Operations to Safety Management in Ports, MTS Conference 2001, Washington D.C., USA, www.risk-support.co.uk/vmt_MTS2001.pdf

4. U.S. Department of Transportation Federal Aviation Administration Air Traffic Organization, Safety Services (2006), Safety Risk Management Guidance For System Acquisitions, http://fast.faa.gov/toolsets/SafMgmt/docs/SRMGSA.pdf

5. Zuijderduijn C. (1999): Risk Management by Shell Refinery/ /Chemicals at Pernis, SEVESO 2000 European Conference, Athens, Greece.

Author's Biography:

Erceg Tonci was born in Split in 1980. In 2003 he graduated from the Faculty of Maritime Studies after which he was employed as deck cadet and later as deck officer by MTMM Ltd. and OSG Inc. After completing first phase of his seagoing career he is employed by the Faculty of Maritime Studies.

Lusic Zvonimir M.Sc was born on December 06th 1971, in Trogir (Croatia). After two years on the Marine College in Split and successful graduation in 1993, he went to sea, as deck cadet. In 1994, after one year of sailing, he resumed education on the Marine Faculty in Split-navigation course and finished the same in 1997. Meanwhile he obtained deck officer license and started to sail as third officer on the Merchant Marine vessels. From 1997 actively began his seagoing career, until 2002. He sailed mainly as deck officer on different types of large ocean going vessels. In 2002 he joined the Marine faculty in Split, first as an associate

(assistant) in teaching process, and from May 01, 2005 as a lecturer with full time job. Also, until May 01, 2005 he was crew agent for the Hanseatic Shipping Company from Cyprus. The postgraduate master's degree study he had started in 2003, he successfully finished on May 17th 2006. He is in possession of the valid Chief mate license for vessels of unlimited tonnage and all required STCW certificates.