RISK ASSESSMENT OF CHEMICALS LEAKAGE IN STORAGE TANK: A CASE STUDY OF FACTORY IN SARABURI PROVINCE

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Abstract

This article aimed at analyzing and identifying the hazards by assessing the risk of chemical spills of a plant in Saraburi. The data had been correct through the Walk-Through Survey technique and related study, document and research. The fault tree analysis (FTA) and risk assessment had been employed to analyze the data and recommend the guidance of reducing the risk and potential hazards. The results showed that the cause of chemical leakage was from the operation and the damage of the tanks, chemicals and components. In addition, causes from operation can also be divided into 2 sub-causes that can lead to chemical leaks, these can include operational standards and workers' understanding toward the correct practice of chemicals. Therefore, the preventive and corrective approach for this study consists of 3"E" engineering principles. Firstly, the engineering approach is necessary to assess the risk when changes or related activities occur in the work process. Secondly, the education approach has shown that there is a need to provide training program in enhancing the worker's understanding towards the hazardous chemical usage. Lastly, the enforcement is defined as a standard of safe operation, including control measures forcing worker to strictly follow.

Keyword: Risk Assessment, Chemicals Leakage, Saraburi Province

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1. Introduction

A study of chemical leaks from a storage tank from a case in Saraburi plant found that most of possibility of chemical leaks is from the process of generating electricity and steam. The production process involves a lot of parts, such as production control, such as electricity and steam, human resource, cost control, and environmental and safety management. Especially in terms of security, the organization must control the hazards that may occur in the workplace associated with the chemical in the plant. In addition, the organization must prevent the potential problems and impact communities in the immediate vicinity. To prevent accidental work that could result in direct and indirect loss, the organization must analyze the risk of chemical hazards by using the hazard identification techniques which are governed by the laws of Thailand. In line with this, the researcher is interested in studying about the risk assessment of chemicals leakage in storage tank by using the fault tree analysis (FTA) in order to find out how to prevent future accidents (Department of Industrial Works, 2003).

2. Research objectives

This study had objectives to analyze and identify the hazards of chemicals and risk by assessing the risk of chemical spills of a plant in Saraburi and recommend the guidance of reducing the risk and potential hazards.

3. Related research and theories

3.1 Risk assessment

Risk assessment refers to the process of analyzing the underlying causes that represent the individual circumstances of an accident. The results of the analysis will be in the form of risk level. This is based on the results of the chance and severity of each situation. The most commonly used technique for analysis is the fault tree analysis (FTA), a tool used to identify hazards that are critical to accidents that occur or are expected to occur. The FTA is a tool that can be used to analyze the cause of accidents by thinking backward to the root causes based on a logically based principle. This technique starts from the analysis of accidents or serious accidents that occur or are expected to occur by considering the first occurrence of events and seek out the sub events of that causes of accidents. The process will be terminated when the cause of the incident is profoundly found to be the causes of a defect in the machinery or a failure of the operation (Simachokedee & Chalermjirarat, 2007).

The risk assessment process is an analysis of the potential and severity of identified hazards. This may cause fire, explosion or chemical leakage. The risk assessment is the way to rank the risk degree which starts from a low level of risk or an unacceptable risk in order to control the risk. The risk assessment uses the following criteria (Department of Industrial Works, 2003):

1) Consider the chance of occurrence by setting 4 opportunity level identifying the more or less chance of harm, as shown in Table 1.

2) Consider the severity of incidents of how much the impact on individuals, communities, property or the environment is likely to be. The severity level is rated as 4 levels as shown in Table 2.

3) Manage the risk level by considering the outcome of the opportunity level with being multiplied by the severity of the impact on the individual, community, property or environment. Then, compare the risk level. If the risk level is higher than others, that risk will be selected as the risk to be assessed. The level of risk is classified into four levels, as shown in Table 3.

Table 1 Levels of chance of harm events

Level 1	There is no chance of harm occurrence within 10 years or more.
Level 2	There is low chance of harm occurrence, such as occur 1 time within 5-10 years.
Level 3	There is moderate chance of harm occurrence, such as occur 1 time within 1-5 years.
Level 4	There is high chance of harm occurrence, such as occur 1 time within 1 year.

Table 2 Consideration of severity of dangers and impacts

Level	**Severity**	**Impact**			
		Individual	**Community**	**Environment**	**Property**
1	Low	Slight injury at the need of first aid only	There is no or less impact on the community.	There is no or less impact on the environment.	There is no or less impact on the property.
2	Moderate	Injury at the need of medical treatment	There is impact on the community and requirement of short recovery.	There is impact on the environment and requirement of short recovery.	There is moderate impact on the property, but it can continue operating.
3	High	Severe injury	There is impact on the community and requirement of longer recovery.	There is severe impact on the environment and requirement of longer recovery.	There is high impact on the property and it cannot continue operating.
4	Highest	Severe injury at the level of disordered level	There is severe impact on the community and requirement of solution from governmental agencies.	There is highly severe impact on the environment and requirement of longer recovery.	There is high impact on the property and entire production must not be operated.

Table 3 Risk level definition

Risk Level	Result	Definition
Level 1	1 – 2	Rare risk
Level 2	3 – 6	Acceptable risk, but the control measurement must be reviewed.
Level 3	8 – 9	High risk, the risk reduction measurement must be manipulated.
Level 4	12 –16	Unacceptable risk, the entire production must be stopped and immediate solution must be manipulated.

3.2 Problem solution and risk reduction

The accident is based on the interaction between the three components, including person, machine and environment. The first is "person". In the production of each piece, the workers need to decide which one to perform in order to accomplish their goals. In order to make a decision, one must always take the risk. Therefore, the workers must have sufficient information to choose how they will work to achieve their goals. The main cause of the risk of dust explosion in the baking cassette is the welding. This will cause the source of ignition or heat in the production process (Chuenbarn & Hansupalak, 2012). In addition, the meeting among the staff in aluminum injection molding section before the start of the work can help reduce the accident (Mongkoltae, Sudsakorn & Srinophakun, 2009). The second is the machine. The machine or equipment used in the production must be ready and safe to operate. If the equipment or machinery is poorly designed or lack good maintenance, it will cause malfunction. This will lead to accidents. Indeed, the equipment or machinery for aluminum injection molding should be checked daily and monthly. Machine maintenance is required for a 6month and 1 year inspection. Also, the mold testing must be performed at all times and the machine or equipment must be sufficient for the work (Mongkoltae, Sudsakorn & Srinophakun, 2009). Lastly, the third is the environment. The work environment is an important factor that causes the operator to crash in the workplace and it results in an accident.

4. Research Methodology

This research is an action research. The details of research operation are as follows.

4.1 Research tools

Research tools consists of risk assessment and hazard identification. It applied from the Department of Industrial Works regulations on hazard identification, risk assessment and risk management plan (2000) (Department of Industrial Works, 2003).

4.2 Research operation

4.1.1 Study, research and collect documents related to the use and storage of chemicals in the production process.

4.1.2 Scope the study by analyzing the chemical process in the production process to achieve research objectives.

4.1.3 Collect the data and record the study in the field with the Walk-Through Survey technique and use the risk assessment and hazard identification to collect information for hazard identification and suggest the risk prevention and recommendation.

4.1.4 Summarize and analyze the data from risk assessment by using descriptive analysis and interpreting the results to be consistent with the research objectives.

4.3 Scope of the study

This research aimed assessing and identifying risk and hazard of chemicals by considering the study, research and documents related to the use and storage of chemicals in the production process as well as the observation of workers' operation in tne prodiction process. In this study, the researcher lacks the interview of related person. In addition, the study area of this research is limited to the area of production part including the other parts such a management division is ignored. Lastly, the technique used in data analysis is only the employment of the the fault tree analysis (FTA).

5. Results

This study uses the fault tree analysis (FTA) as the risk assessment by assessing the risk of hazardous chemical spills to determine the hazardous substances that can affect the health of the person in the area and the surrounding environment. The FTA methods can be used to analyze risks and to isolate them based on factors and situations. This study can be explained in Table 4 and Figure 1. The result of this study indicated that the occurrence of chemical spills is caused by the operation and the damaged chemical containers and components. In addition, operation causing the risk can also be divided into sub-causes that lead to chemical leaks, including operational standards in the work places. The results showed that there are no standards or correct practices for the chemicals usage. Also, the workers do not understand or know about the hazards of chemicals before they start working.

Table 4 Factors and situations of chemical leaks from storage tank

Group of Factors	Situation (s)
1) physical factors	1.1) Leakage / deterioration tank
	1.2) Good quality rubber ring
	1.3) Untighten pipe
	1.4) Problem at automatic control system

Table 4 Factors and situation of chemical leaks from storage tank (Cont.)

Group of Factors	Situation (s)
2) personal factors	2.1) Erroneous operation
	2.2) Lack of supervision from the supervisor
	2.3) Lack of danger awareness communication
	2.4) Lack of operation understanding
	2.5) Lack of understanding on chemicals danger
3) Operation factors	3.1) Lack of correct operation standard

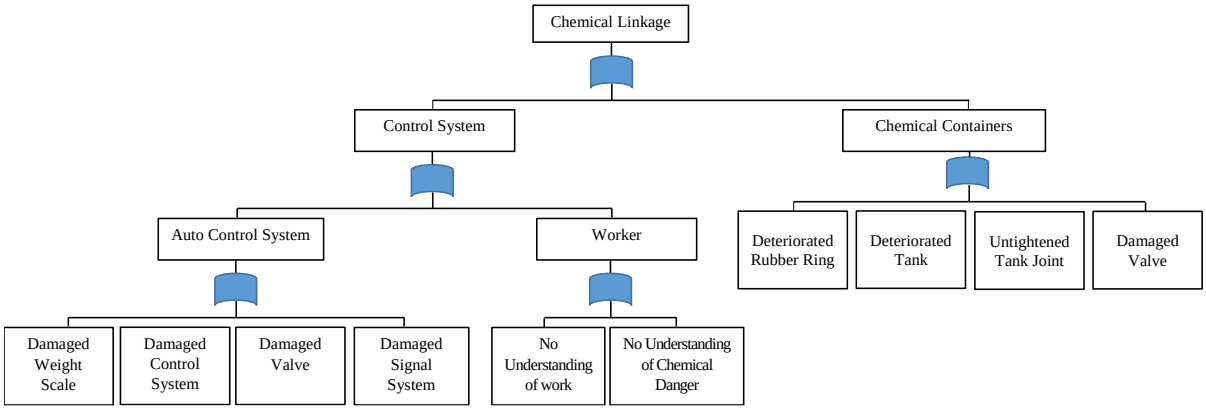

Figure 1 Chemical leakage risk assessment by using fault tree analysis techniques

Risk assessment using the FTA technique, as illustrated in Figure 1, can be used to identify the cause of an accident in various reasons and to cover the risks that could lead to more effective accident prevention. In addition, the researcher assessed the risks according to hazard identification and risk assessment which the details are shown in Table 5.

Table 5 Risk factors for chemical leaks by using fault tree analysis techniques

Causes	Opportunity	Severity			
		Individual	Community	Environment	Proerty
Deteriorated tank	2	3	2	2	2
Deteriorated tank assembly equipment	3	3	2	2	2
Untighten pipe	3	3	2	2	2
Automatic control system problems in the weighing machine.	2	2	2	3	3
Problem with the alert signal	2	2	2	3	3

Table 5 Risk factors for chemical leaks by using fault tree analysis techniques (Cont.)

Causes	Opportunity	Severity			
		Individual	Community	Environment	Proerty
Worker not understanding the operation method	3	3	3	3	3
Worker not understanding the hazards of chemicals	3	3	3	3	3
Lack of operation standard	3	2	2	2	2

When the researcher know about the risks and probabilities of chemical leaks, the researcher must utilize the results to set the plan and measures to reduce accidents or losses in order to create the prevention and problem solution. The prevention and problem solution can include 3 "E" engineering principles, namely engineering, education and enforcement. In engineering part, the study found that organization must assess risk when the changes in activities occur in the work process. In education part, the organization must provide the training program to the workers to review the knowledge and understanding of hazardous chemical relevance. And in terms of enforcement, the organization must determine how to operate safely by providing the control measurement to enforce the workers to strictly follow. The details are shown in Figure 2-4, respectively.

Figure 2 Daily monitoring and observing the machines

Figure 3 Training program on risk assessment and operation related to chemical hazards

Figure 4 Training program on emergency preparedness for chemical spills

6. Conclusion, Discussion and Recommendations

6.1 Conclusion and discussion

From the study done by the fault tree analysis (FTA), the results indicated that the risk is in high level (Level 3) which it consisted as of following situation including 1.4) the automatic control system problems, 2.1) the employees misbehaving and 3.1) the none of standard operating procedures. The researchers have chosen the underlying causes of accidents due to lack of proper operating regulations or standards because the operating regulations or standards to prevent the accidents are very important. If there are no control measures and standards and the risk reduction is fail, there will be a great risk occurrence severely affecting the operation and organization. The results of this study are consistent with the study of leakage of ammonia from storage tank in frozen seafood factory. The reasons behind this leakage can cover, for instant, joints, pipes, rust, corrosion at the connection point, disoperation cooling valves and voltage, defective staff, broken tanks and worn-out tire rings. The results of this study can lead to set the evacuation measures or escaping behind the behind or inside the building as well as the emergency plans for chemical incidents (Rukkhamon, Thongyai & Maneelok, 2013).

In addition, the results of the study are consistent with the study of risk assessment about the linkage of exploration materials with natural gas production for road transport which found that most of risk occurrence is related to the lack of specific operation requirements (Dapthuk, 2014). From this study result, it can affect the manipulation of risk management plan.

The results of this study also indicated that the hazard assessment of industrial chemical laboratories presents a high level of risk, which may result in a fire or explosion hazard from the classification of hazardous chemical storage. The results of this study, as a result, can generate the accident prevention and reduction measurement (Petsungnern et. al., 2016). Also, a risk assessment of exposure to chemicals has also found that in the chemical laboratory, there are various workers who need to know the details of the correct operation procedures, including the operating manual (Husin et. al., 2012). The study results done by Dapthuk (2014) showed that the assessment of the risk of leakage of gas from power plants requires the establishment of surveillance measures and the preparation for an

emergency situation to prevent accidents or incidents that may occur (Shao & Duan, 2012). The study done by Vichien and Karnchana (2012) found that accident prevention can be applied with the engineering principles including engineering, education and enforcement. From that, the researcher can conclude that the workplace safety risk assessment is a fundamental factor in improving quality of work and encourage entrepreneurs to create safety for workers which this conclusion can be consistent with the study done by Bunprom and Thirawanutpong (2013).

6.2 Recommendations

6.2.1 Recommendations for practitioners

1) Risk management must be accomplished with the involvement of the management and operational departments.

2) After the implementation of risk management plan, the summary of the implementation must be reported to the executive in order to remain knowing the plan development.

3) When the risk analysis is considered the risk at an acceptable level which means that the risk control measures are adequate, the organization then should remain the practical measure in the workplace.

4) However, if the risk level is unacceptable, the organization must find the new measures or methods to help reduce the risk.

6.2.2 Recommendations for future researches

1) There should be an interview of the workers and related person in the workplace in order to get the indebt detail.

2) There should be an application of other problem cause identification techniques and compare with the currently used techniques. The more techniques can generate the efficient result.

3) There should be a follow-up research to identify the result after the measure implementation. The results may yield in unexpected outcome.

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