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SAFETY MANAGEMENT SYSTEM FOR HAZARDOUS SUBSTANCE TRANSPORTATION BASED-ON RISK ANALYSIS

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for the Degree of Master of Engineering Program in Engineering Management
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งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาระบบบริหารความปลอดภัยสำหรับการขนส่งวัตถุอันตราย บริษัทที่ใช้เป็นกรณีศึกษาเป็นผู้ประกอบการขนส่งวัตถุอันตรายชั้นนำของเมืองไทย ซึ่งในระยะเวลาสองปีที่ผ่านมาบริษัทมีอัตราการเกิดอุบัติเหตุหรือเหตุการณ์ในขบวนการจัดส่งในอัตราที่สูงอย่างต่อเนื่อง

ในเบื้องต้นผู้เขียนได้รับความอนุเคราะห์จากผู้บริหารของบริษัทที่เป็นกรณีศึกษาในการจัดตั้งคณะทำงานระบบบริหารความปลอดภัย ซึ่งประกอบไปด้วยตัวแทนจากฝ่ายต่างๆที่เกี่ยวข้องของบริษัท รวมถึงตัวผู้เขียนเอง ระบบบริหารความปลอดภัยที่ได้มีการนำเสนอในวิทยานิพนธ์ฉบับนี้ได้มีการพัฒนาโดยอ้างอิงมาตรฐาน British Standard BS8800 (1996) คณะทำงานฯ ได้ใช้วิธีการวิเคราะห์แบบ Gap analysis โดยใช้ตารางรายการตรวจสอบ เพื่อหาความต้องการเพิ่มเติมของระบบปัจจุบัน ระบบบริหารความปลอดภัยเป็นระบบที่สามารถระบุ วิเคราะห์ และทำให้มีข้อมูลที่ทันสมัยของความเสี่ยงทั้งหมดของขบวนการจัดส่งที่ดำเนินการอยู่ และลดความน่าจะเป็นของการเกิดเหตุ รวมไปถึงการบรรเทาผลกระทบจากอุบัติเหตุหรือเหตุการณ์ผ่านขั้นตอนการวิเคราะห์ความเสี่ยง

ขั้นตอนถัดไปคือการวิเคราะห์ความเสี่ยงของอุบัติเหตุหรือเหตุการณ์ประเภทความรุนแรงสูงที่สามารถหลีกเลี่ยงได้ที่อุบัติขึ้นในช่วงระหว่างปี พ.ศ. 2546 ถึง พ.ศ. 2547 จากการระดมสมองและการวิเคราะห์อาการขัดข้องและผลกระทบ Failure Mode and Effect Analysis (FMEA) คณะทำงานฯจึงได้นำเสนอข้อเสนอแนะซึ่งบางข้อเสนอแนะได้นำไปสู่การปรับปรุงนโยบายและแผนปฏิบัติงาน โดยมีเจ้าหน้าที่ที่เกี่ยวข้องเป็นผู้นำไปปฏิบัติเพื่อให้ระดับความเสี่ยงอยู่ในระดับที่ยอมรับได้ในที่สุด

ผลของการนำระบบบริหารความปลอดภัยและข้อเสนอแนะไปประยุกต์ใช้ อาจไม่สามารถบ่งชี้ได้อย่างชัดเจนว่าสิ่งที่ได้นำเสนอไปสามารถลดอัตราและผลกระทบทางการเงินที่ได้รับจากอุบัติเหตุหรือเหตุการณ์ประเภทความรุนแรงสูงที่สามารถหลีกเลี่ยง แต่การมีระบบบริหารความปลอดภัยทำให้สามารถติดตาม บ่งชี้ และวิเคราะห์อุบัติเหตุหรือเหตุการณ์เพื่อลดความน่าจะเป็นของการเกิดดังกล่าว และบรรเทาผลกระทบจากอุบัติเหตุหรือเหตุการณ์

ภาควิชา...ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต... ลายมือชื่อนิสิต.....

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467 16199 21 : MAJOR ENGINEERING MANAGEMENT
KEY WORD : SAFETY MANAGEMENT SYSTEM / RISK ANALYSIS / FMEA / HAZARDOUS SUBSTANCE TRANSPORTATION

KITTIPONG PUTTHAPORNMONGKOL : SAFETY MANAGEMENT SYSTEM FOR HAZARDOUS SUBSTANCE TRANSPORTATION BASED-ON RISK ANALYSIS. THESIS ADVISOR : ASST. PROF. PRASERT AKKHARAPRATHOMPHONG, 102 pp. ISBN 974-14-1930-9.

The objective of this study is to develop a Safety Management System (SMS) for hazardous substance transportation. The selected case study company is a leading hazardous chemical transportation operator in Thailand, however, for the past two years the company experienced persistently high accidents/incidents rate in its handling and delivery process.

Primarily, with the help from the company management, the author was able to set up a SMS Working Team, comprising representatives from various departments of the company and the author. The SMS proposed in this study was developed based on using British Standard BS8800 (1996) as a reference model. The SMS working team conducted a gap analysis using checklist to determine the additional requirement to the current system. The proposed SMS is a system to identify, analyze and update all existing risks of on-going delivery operations and to reduce occurrence probability and mitigate the consequences of safety accidents/incidents through comprehensive risk analysis process.

Next step is to conduct risk analysis on major severity avoidable accident/incident cases which occurred between January 2003 and December 2004. From brainstorming and Failure Mode and Effect Analysis (FMEA), recommended actions were proposed and some of which were adopted into revised policy and procedures by the SMS working team. The proposed recommended actions are carried out by the related officer to make sure that the acceptable risk level is eventually achieved.

The implementation results of the proposed SMS and recommended actions may not clearly indicate that the proposed SMS and recommended actions significantly reduce the rate and financial impacts cause by major severity avoidable accident/incident, but with the SMS in place, accident/incident can now be track, identify and analyze, in order to reduce occurrence probability and mitigate the consequences of accidents/incidents.

The Regional Centre for Manufacturing System Engineering Student's signature.....

Field of study ...Engineering Management..... Advisor's signature.....

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CHAPTER I
Introduction

1.1 Introduction

At present, the globalization of the world economy, the intensity of competitive environment has forced many firms to focus on supply chain management to cope with highly increasing competition. The basic parts of supply chain management are the logistic, operation, sales and service functions. The logistic function has been receiving increasing importance as a critical supply chain management component. The main reason is due to the significant impact of material costs on profits, increased in fuel price, and a growing emphasis on Just-In-Time (JIT) production. The vital goals of logistic departments consist of obtaining and delivering the product at the right cost in the right quantity with the right quality at the right time to the right source. In the past, the aims of most transportation company emphasized only on delivering goods at low cost and on-time. However, recently the increased in safety requirement in the distribution and delivery process has become even more important, in particular the hazardous chemical products.

With the current focus on safety, the chemical manufacturer gives great emphasis on the safety standard of their service providers; therefore most of the chemical manufacturers come up with different ways and methods to evaluate the competency of their service providers. And with increasing competition from new entrants, in order to differentiate themselves from the new entrants, therefore service providers have to prove that they are not only competitive on cost alone, and excel in safety as well

1.2 Background of the case study company

The case study company, ABC Transportation Co., Ltd., established in 1995 is a leading hazardous substance transportation operator in Thailand. ABC Transportation was established for serving the transportation needs in chemical business on the recognition that safety in this business is not only concentrated on the

production process and use, but distribution and safe delivery must unavoidably be concerned. Follow the mentioned principle; the company has commenced its chemical transportation operations in the highest standard of safety practices with most reliable vehicles, containers, and equipment which certainly include timeliness delivery in the most appropriate routes. Maintaining high quality delivery standard, the company carefully issued numerous safety standards covering specification of vehicles and equipment, type and characteristic of chemical container, transportation route and schedule, recruitment of appropriate personnel, training and educating of staff to aware the hazard and careful handling of each chemical, as well as controlling and monitoring to conform with all the working procedures. Most of the customers are multi-national companies which are leaders in the chemical sector; therefore quality is the most important element of the company's reputation.

Organization chart of the case study company:

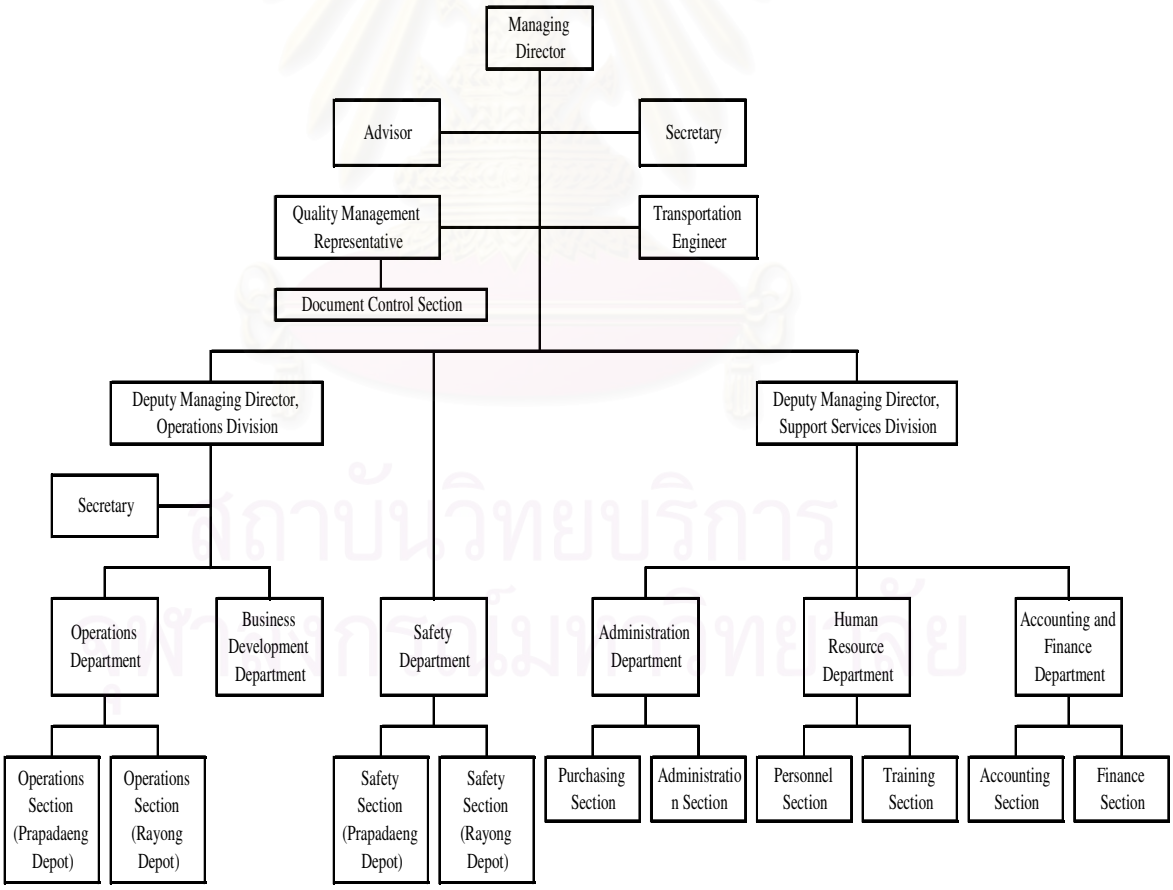


Figure 1.1: ABC Transportation organization chart

1.3 Statement of Problem

ABC Transportation paying very much attention towards its service's quality, therefore the management of the company decided to obtain ISO9001:2000 in 2002. In the mean time, the company had been expanding aggressively for the past years, it now had more than 10 clients and over 21 different kinds of chemical to transport and handle. However, for the past two years the company experienced persistently high accidents/incidents rate in its handling and delivery process. This problem is a major concern to the management of the company, because it not only cost the company in financial aspect but also the image and the opportunity to expand its business.

Currently, the safety department prepares monthly accidents/incidents report. The monthly report includes the number of accidents/incidents, severity, brief description, reason and corrective actions or preventive measures for each accident/incident. The accidents/incidents from the monthly accidents/incidents report during period of January 2004 to December 2004 can be summarized into Table 1 below.

Table 1-1: Accidents/Incidents rate by quarter for Year 2004

Type of Accidents/Incidents		1st Quarter 2004	2nd Quarter 2004	3rd Quarter 2004	4th Quarter 2004	Total	Average
1. Minor	Avoidable accidents/incidents	12	4	10	5	31	7.75
	Unavoidable accidents/incidents	3	11	3	6	23	5.75
2. Medium	Avoidable accidents/incidents	4	4	7	7	22	5.5
	Unavoidable accidents/incidents	5	4	4	4	17	4.25
3. Major	Avoidable accidents/incidents	1	2	1	3	7	1.75
	Unavoidable accidents/incidents	1	0	3	0	4	1
Total Avoidable accidents/incidents		17	10	18	15	60	15
Total Unavoidable accidents/incidents		9	15	10	10	44	11
Total accidents/incidents		26	25	28	25	104	26

The classification of accident/incident severities are as follows:

Table 1-2: Classification of accident/incident severities

Severities	Financial Loss	Injury	Goods Damage
Minor	Less than THB 5,000	Minor Injury but does not required Medical Doctor (MD) examination	Less than 50 Kg.
Medium	Between THB 5,001 - 50,000	Injury, Required MD examination but does not require leave from work	Between 51 - 500 Kg.

(Table1-2 continued)

Severities	Financial Loss	Injury	Goods Damage
Major	More than THB 50,001	• Injury, Required MD examination and Leave from work required • Organs Loss • Death	More than 500 Kg.

To derive an estimate of the financial impacts of avoidable accidents/incidents for the period January 2004 to December 2004, the following impact categories were considered:

- Vehicles/Equipments Repair
- Cargo Damage
- Injuries and Deaths
- Opportunity Loss
- Involved Parties' Vehicles/Equipments Repair
- Others

Impact estimates not readily available from the accounting department, such as opportunity loss, were assumed to be 2,000 baht per day. Finally, the financial impacts estimates of the accidents/incidents that occurred during the period of January 2004 to December 2004 are compiled and summarized into different severities (Minor, Medium and Major) in Table 1-3 below.

Table 1-3: Summary of financial impact estimates of avoidable accidents/incidents by quarter for Year 2004

Period / Severity	1st Quarter 2004	2nd Quarter 2004	3rd Quarter 2004	4th Quarter 2004	Total (THB)	Average (THB)	Average (THB/1,000,000 KM)
Minor	32,160	6,000	24,360	20,000	82,520	20,630	2,705.04
Medium	163,448	70,000	136,700	84,000	454,148	113,537	14,887.18
Major	308,000	416,000	46,000	290,000	1,060,000	265,000	34,747.29
Total					1,596,668		

From Table 1-1 and Table 1-3, it can be conclude that about 60% of the total accidents/incidents are avoidable accidents/incidents, and about 67% of the financial impact estimates of avoidable accidents/incidents are of Major-severity.

1.4 Objective

To develop a safety management system for hazardous substance transportation.

1.5 Scope of the study

1. The study will be conducted base on the hazardous substance delivery process which is responsible by operations department of the case study company.
2. The study will focus on the avoidable accidents/incidents of Major-severity which causes considerable financial impact to the case study company.
3. The study will analyze and update all existing risks of on-going delivery operations and to reduce occurrence probability and mitigate the severities of accidents/incidents through comprehensive risk assessments.
4. The developed safety management system will include:
   - Internal control procedure which proposed new rules and regulations on safety procedure for delivery operations.
   - System for training and testing drivers, the inspection of vehicles and equipments, and the accreditation of drivers and carriers so that all operations are carried out safely.
   - Procedure to report and analyze incidents to ensure effective incident investigation, reporting and follow-up.

1.6 Methodologies

1. Study related journals, literature and information from the Internet.
2. Interview with the concerned authorization to realize the current situation and problems of the existing dispatch process and documents.
3. Data collection of the related information.
4. Use risk assessment tools (such as brainstorming, FMEA etc.) to analyses the failure.
5. Design the safety management system and other functions.
6. Develop a safety management system.

7. Implementing the proposed system.
8. Summarized result and formulate suggestions.
9. Prepare for presentation and final report.

1.7 Expected Benefits

1. Reduction of the rate and severity of transportation fatalities and injuries in hazardous substance transportation and the money loss associated with avoidable accidents/incidents for the case study company.
2. Create good image for the case study company, which will be advantageous towards attracting new clients.
3. The developed system can be use with other organization which may or may not be in the same industry as the case study company.

1.8 Thesis Schedule

Items	Task Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	Analyze Company's background									
2	Study of related literature and literature review									
3	Interview with the concerned authorization									
4	Collect relevant data and related information									
5	Analysis of the failure									
6	Design of the safety management system									
7	Develop the safety management system									
8	System Implementation									
9	Summarized result and formulate suggestions									
10	Prepare for presentation and final report write-up									

CHAPTER II

Literature Review

2.1 Introduction

This chapter introduced theories and techniques that are applied to this thesis. The chapter begins with the definition and introduction to Failure Mode and Effect Analysis (FMEA). It is followed by literature surveys. The literature surveys are taken from academic papers and past master degree thesis works

2.2 Failure Mode and Effect Analysis (FMEA)

FMEA was originally developed and used by the aerospace industry during the Apollo program in the 1960s. Later on, the automotive industry adopted FMEA as a required component of the advanced quality planning process.

The followings are a few definitions of FMEA from academic books and published papers.

FMEA is a design discipline and a quality-planning tool used to investigate the sources and the consequences of failures on the operation of a system. FMEA is a systematic and analytical process that combines top down and bottom up analysis. From the top, the system functional goals are decomposed into sub-system goals and, from the bottom, the component behaviors are expressed as the functions required to realize the goals of each sub-system. Failure modes are then defined, and the resulting behavioral changes are classified according to their effect on goal achievement. (Barkai 1999)

FMEA provides a systematic method of resolving the questions: "How can a process or product fail? What will be the effect on the rest of the system if such failure occurs? What action is necessary to prevent the failure?" (Dovich)

FMEA is an inductive process that examines the effect of a single point failure on the overall performance of a system through a "bottom-up approach". FMEA should be performed iteratively in all stages of design and operation of a system, however, engineering system design should stress safety considerations early in the design process since it is more difficult and costly to rectify faults later. (Wilcox)

From the above definitions, it can be summarized that FMEA is an analysis tool for identifying sources and consequences of a failure and actions to prevent failure, whether using a top-down or bottom-up approach.

2.2.1 FMEA Process

There are many approaches to conducting an FMEA. Depending on the complexity of the problem and approach taken, the process can involved as little as 5 steps to as many as 15 steps. The process adopted by this thesis will followed the 9 steps process proposed by SEQ group. Figure 2.1 summarizes the 9 steps into a process flow.

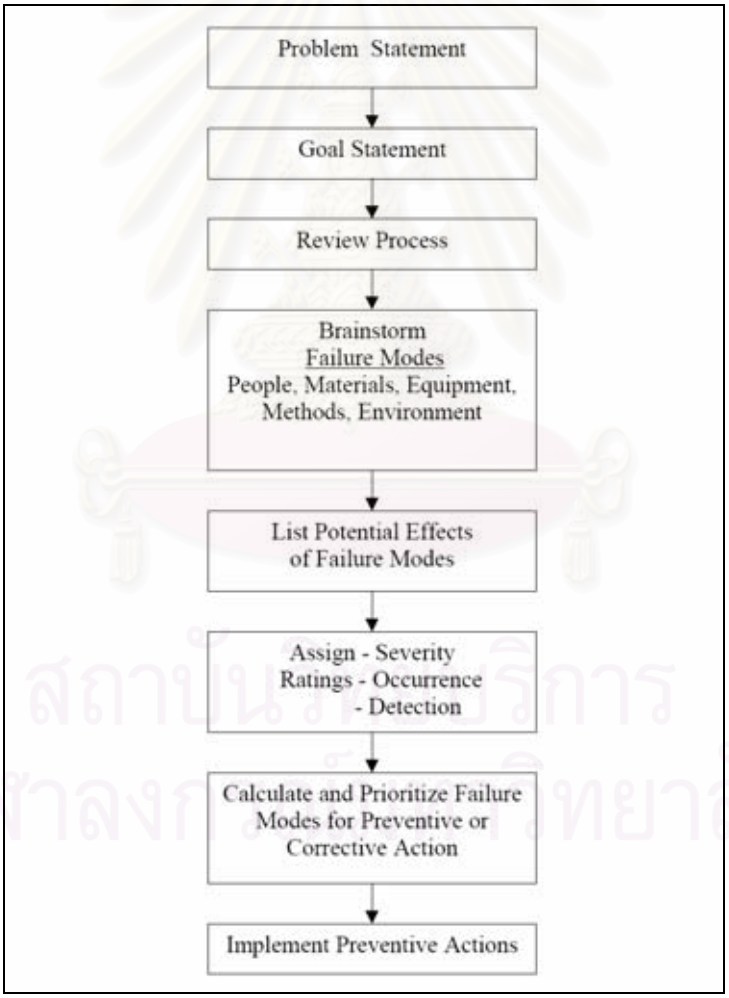


Figure 2.1: FMEA Process Problem Solving

Source: SEQ Group, Snap-On Incorporated Standard on FMEA Process for Quality Problem Solving (Failure Mode & Effect Analysis)

The following is the description of 9 steps FMEA [*Adapted from: SEQ Group, Snap-On Incorporated Standard on FMEA Process for Quality Problem Solving (Failure Mode & Effect Analysis)*

Step 1 – Process Review

To ensure that everyone on the FMEA team has the same understanding of the process that is being worked on, the team should review a detailed flowchart of the operation if they are conducting a process FMEA.

If a flowchart is not available, the team will need to create one prior to starting the FMEA process.

With the flowchart in hand, the team members should familiarize themselves with the product or process. For a product FMEA, they should physically see the product or a prototype of the product. For a process FMEA, the team should physically walk through the process exactly as the process flows.

It is helpful to have an "expert" on the product or process available to answer any questions the team might have.

Step 2 – Brainstorm Potential Failure Modes

Once everyone on the team has an understanding of the process (or product), team members can begin thinking about potential failure modes that could affect the process. A brainstorming session will get all of those ideas out on the table. Team members should come to the brainstorming meeting with a list of their ideas. In addition to the ideas members bring to the meeting, others will be generated as a result of the synergy of the group process.

Because of the complexity of some processes, it is best to conduct a series of brainstorming sessions, each focused on a different element (for example; people, methods, equipment, materials and the environment) of the product or process. Focusing on the elements one at a time may result in a more thorough list of potential failure modes.

It is not unusual to generate dozens of ideas from the brainstorming process. In fact, that's the objective!

Once the brainstorming is complete, the ideas should be organized by grouping them into like categories. The team must decide the best categories for grouping, as there are many different ways to form groups with failure modes. The team can group them by the type of failure (e.g., electrical, mechanical, human error), where on the process

the failure occurred, or the seriousness (at least the team's best guess at this point) of the failure. Grouping the failures will make the FMEA process easier to work through. Without the grouping step, the team may invest a lot of energy jumping from one aspect of the process to a completely different aspect of the process and then back again. An easy way to work through the grouping process is to put all of the failure modes onto self-stick notes and post them on a wall so they are easy to see and move around as they are being grouped.

The grouping also gives the team a chance to consider whether some failure modes should be combined, because they are the same or very similar to each other. When the failure modes have been grouped and combined, if appropriate, they should be transferred onto the FMEA sheet.

Step 3 – List Potential Effects of Each Failure Mode

With the failure modes listed on the FMEA worksheet form, the FMEA team reviews each failure mode and identifies the potential effects of the failure should it occur. For some of the failure modes, there may be only one effect while there may be several effects for other failure modes.

This step must be thorough, because this information will feed into the assignment of risk ratings for each of the failures. It is helpful to think of this step as an *if-then* process: *If* the failure occurs, *then* what are the consequences.

Step 4, 5 and 6 – Assigning Severity, Occurrence and Detection Ratings

Each of these three ratings are based on either a 5-point or 10-point scale, with 1 being the lowest rating and 5 or 10 being the highest.

It is important to establish clear and concise descriptions for the points on each of the scales, so that all team members have the same understanding of the ratings. The scales should be established before the team begins the rating process. The more descriptive the team is when defining the rating scale, the easier it should be to reach consensus during the rating process.

A generic rating system for each of the scales is provided in Tables 1, 2 and 3. This system should be customized by the team for their specific FMEA project.

Even if the rating system is clear and concise, there still may be a disagreement about the rating for a particular item.

Step 4– Assign a Severity Rating for Each Effect

The severity rating is an estimation of how serious the effects would be if a given failure did occur. In some cases it is clear, because of past experience, how serious the

problem would be. In other cases, it is necessary to estimate the severity based on the knowledge and expertise of the team members.

Because each failure may have several different effects, and each effect can have a different level of severity, it is the effect, not the failure that is rated. Therefore, each effect should be given its own severity rating, even if there are several effects for a single failure mode.

Step 5– Assign an Occurrence Rating for Each Failure Mode

The best method for determining the occurrence rating is to use actual data from the process. This may be in the form of failure logs or even process capability data. When actual failure data are not available, the team must estimate how often a failure mode may occur. The team can make a better estimate of how likely a failure mode is to occur and at what frequency by knowing the potential cause of failure. Once the potential causes have been identified for all of the failure modes, an occurrence rating can be assigned even without failure data.

Step 6 – Assign a Detection Rating for Each Failure Mode and/or Effect

The detection rating looks at how likely we are to detect a failure or the effect of a failure. We start this step by identifying current controls that may detect a failure or effect of a failure. If there are no current controls, the likelihood of detection will be low, and the item would receive a high rating, such as a 9 or 10. The current controls should be listed first for all of the failure modes or the effects of the failures and then the detection ratings assigned.

Step 7 – Calculate the Risk Priority Number for Each Failure Mode

The risk priority number (RPN) is simply calculated by multiplying the severity rating times the occurrence rating times the detection rating for all of the items.

Risk Priority Number = Severity x Occurrence x Detection

The total risk priority number should be calculated by adding all of the risk priority numbers. This number alone is meaningless, because each FMEA has a different number of failure modes and effects. However, it will serve as a gauge to compare the revised total RPN against the original RPN once the recommended actions have been instituted.

Step 8 – Prioritize the Failure Modes for Action

The failure modes can now be prioritized by ranking them in order from the highest risk priority number to the smallest. A Pareto diagram is helpful to visualize the differences between the various ratings.

The team must now decide which items to work on. Usually it helps to set a cut-off RPN, where any failure modes with an RPN above that point are attended to. Those below the cut-off are left alone for the time being.

Step 9 – Take Action to Eliminate or Reduce the High-Risk Failure Modes

Using an organized problem-solving process, identify actions to eliminate or reduce the high-risk failure modes and make recommendations to the appropriate management level.

2.2.2 RPN Rating Scale and Criteria

RPN to be used in this thesis is calculated by the multiplication of S (severity), O (occurrence), D (detection) as in equation 2-1 using scaled 1-5 for each factor.

$$RPN = S \times O \times D \qquad \text{(Equation 2-1)}$$

Therefore the highest possible risk of each failure mode is 125 and the lowest is 1. The criteria of ranking the scale for severity, occurrence and detection are described in table 2-1, table 2-2, and table 2-3, respectively.

The severities of the accidents/incidents which was initially classified according to table 1-2, are reclassified into 5 categories for the convenient purpose of working out the FMEA values. The reclassification will not have any impact on the values and interpretation of table 1-1 and table 1-3 in Chapter 1 because the reclassification only relevant to Minor and Major severities.

Table 2-1: Ranking scale for severity of potential failure mode

Ranking	Description	Criteria
1	Very Minor	No injury, goods damage is less than 50 Kg. and financial loss is less than THB 5,000.
2	Minor	Minor injury but do not require medical doctor examination, goods damage is less than 50 Kg. and financial loss is less than THB 5,000.
3	Medium	Injury which requires medical doctor examination and leave from work is less than 24 hours, goods damage is between 51 – 500 Kg. and financial loss is between THB 5,001 – 50,000.
4	Major	Injury which requires medical doctor examination and leave from work is more than 24 hours, goods damage is more than 500 Kg. and financial loss is more than THB 50,000.
5	Very Major	Injury which results in loss of organ or death, goods damage is more than 500 Kg. and financial loss is more than THB 50,000.

Table 2-2: Ranking scale for probability and frequency of occurrence

Ranking	Description	Criteria
1	Remote	0 occurrence within the past 1 year
2	Low	1 occurrence within the past 1 year
3	Moderate	2 occurrences within the past 1 year
4	High	3 occurrences within the past 1 year
5	Very High	More than 4 occurrences within the past 1 year

Table 2-3: Ranking scale for detection

Ranking	Description	Criteria
1	Very High	The detection of the existence of a defect is almost a certainty.
2	High	There are controls to detect defects, but there is a small chance of defects not being detected.
3	Moderate	There is only a small chance of detecting an existing defect.
4	Low	Controls in place will not generally detect the existence of a defect.
5	Very Low	A defect will almost certainly escape detection.

2.3 Literature Surveys

1. The Working Group which comprised representatives from the Oil and Petrochemical Industry Technical and Safety Committee (OPITSC) and the Occupational Safety Department, Ministry of Manpower, Government of Singapore developed the Code of Practice on Safety Management System for the Oil, Petrochemical and Chemical Industries.

The Code of Practice represents a standard of good practice and has been prepared with the objective of formulating the discipline to which these procedures should conform. It stipulates requirements for the 14 elements of the Safety Management System as specified in the Thirteenth Schedule of the Factories (Amendment) Act 1999. The 14 elements suggested by the Working Group are:

I. Safety Policy
II. Safe Work Practices
III. Safety Training
IV. Group Meetings
V. Incident Investigation and Analysis
VI. In House Safety Rules and Regulations
VII. Safety Promotion
VIII. Contractors Evaluation, Selection and Control
IX. Safety Inspection
X. Maintenance Regime
XI. Hazard Analysis
XII. Control of Movement and Use of Hazardous Chemicals
XIII. Occupational Health Programs
XIV. Emergency Preparedness

The Code is generally intended for personnel in the Oil, Petrochemical and Chemical industry, especially those involved in the preparation, supervision and execution of processes in major hazardous installations and plants. This Code is also recommended for use by other manufacturing and general industries as appropriate. It forms a basis for audit and review of the Safety Management System.

2. Kuusisto discussed extensively on safety auditing as a systematic method to evaluate a company's safety management system. The author suggested that auditing should cover the entire safety management system, which refers to, all the activities aiming to ensure adequate control of the hazards affecting people, property or the environment. The two main tasks of auditing were identified as 1) compliance verification to establish whether the relevant legal requirements are met, and 2) validation to see whether the correct types of methods are in use, and whether they are effectively implemented. Several methods or tools have been developed for supporting safety auditing. The methods are checklists of the activities to be assessed. Some methods also have criteria for the assessment, as well as a scoring system which produces a numerical estimate of the safety activity level. The aim of the safety audit methods is to help the company's management systematically follow the overall progress in safety control.

3. Joint ECTA-EPCA-CEFIC Working Group proposed recommendations on safety, health and environmental management practices address the different elements of the management systems that chemical logistics service providers should have in place in order to ensure that the transport and associated handling of chemicals is unlikely to have adverse safety, health and environmental (SHE) impacts.

The recommendations apply to the transport of chemicals by the different modes of transport. They also apply to other distribution activities associated with the transport of chemicals, carried out by logistics service providers, such as storage, loading and unloading and to any subcontractors who are working on a contract basis for logistics service providers. The recommendations cover 10 elements of the Safety Management System which are:

I. Commitment and Awareness of SHE-Policies
II. Data, Information and Regulations
III. Risk Assessment and Reduction
IV. Selection and Monitoring of Subcontractors
V. Specification and Maintenance of Equipment
VI. Training
VII. Reporting and Evaluation of Incidents and Accidents
VIII. Emergency Response
IX. Control of Operations

X. Auditing

4. Wilcox discussed the powerful techniques that can be used to perform risk analysis of marine systems. The technique that has been applied in both national and international marine regulations is Failure Mode and Effects Analysis (FMEA). This risk analysis tool assumes a failure mode occurs in a system/component through some failure mechanism; the effect of this failure is then evaluated. A risk ranking can be developed in a more detailed variant of FMEA called Failure Mode and Effects Criticality Analysis (FMECA). The author described FMEA as an inductive process that examines the effect of a single point failure on the overall performance of a system through a "bottom-up approach", which should be performed iteratively in all stages of design and operation of a system, however, engineering system design should stress safety considerations early in the design process since it is more difficult and costly to rectify faults later.

5. Rhyne explained what transportation quantitative risk analysis is, how to communicate risk study objectives to an experienced risk analyst, and how to do a reasonably detailed calculation based on available risk data. The author explains the quantitative risk analysis (QRA) procedure and its application to transportation. Risk analysis methodologies and data uncertainties are also clearly explained. The author also includes an example on a quantitative risk analysis for bulk transport of chlorine by truck and train. The detailed example explores every step of the QRA from preliminary hazards analysis to risk reduction alternatives. This example can be adapted to many practical situations. Methodologies are provided for accident scenario development, frequency and consequence analysis, and risk presentation. The author discussed in-depth on

- Definitions of basic risk analysis terms
- Mathematical formulations for transportation quantitative risk analysis
- Databases for accident rate and frequency, accident force types and magnitudes, container failure probability, and release amounts
- Engineering models for container failure analysis
- Quantification of the risk reduction of modifying container design

- A generalized fault tree that can be easily modified for different types of transportation risk analysis

The discussion of consequence analysis delves into release rates and amounts, airborne dispersion, toxic material effects, exposed populations, and exposure mitigation measures. Analysis results for both individual and societal risks are discussed.

6. Chonlatha Kraiwatnussorn employed FMEA to design and initiate computer software for identifying the failure modes and analyzes the Process FMEA expediently correctly reliably and efficiently. The software FMEA ProFl 1.0 created consists of 5 modules as Information, Options, Failure modes, Work sheet and Recommendation. The result of the program validated by the users in metal automotive part industrial shows the using of database on computer software can help to identify failure mode and increase efficiency of Process FMEA expediently correctly and reliably measured by the users' satisfaction score is raising from status of 62% up to 87% after implementing the FMEA ProFl 1.0

CHAPTER III

Current Situation

3.1 Introduction

This chapter will touches on the background of the problems leading to this research which includes the current business processes, roles of safety department, safety policy, safety related procedures and work instructions before touches on past accidents/incidents data which will summarize and present various effects and root causes of those accidents/incidents

3.2 Core Business Activity

Currently, ABC Transportation core business activity is to transport hazardous substances from customer plants to destination plants or ports. The delivery process can be simplified into the process flow in Figure 3.1 below.

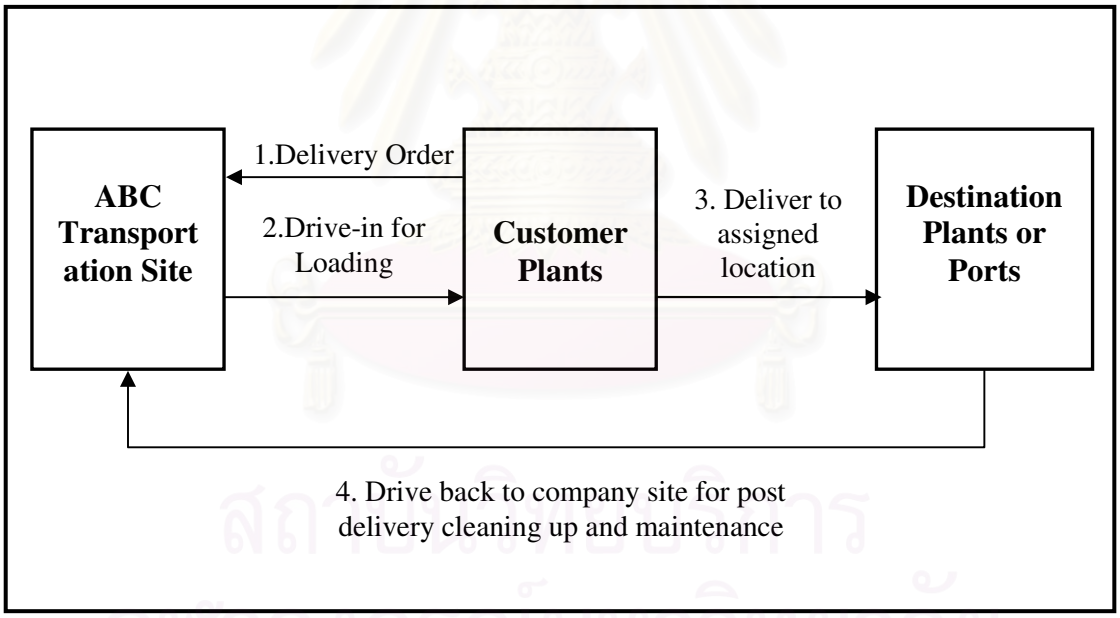


Figure 3.1: Simplified ABC Transportation Delivery Process

ABC Transportation currently had 10 customers and handles 21 substances, which are hazardous and non-hazardous. The list of substances currently handles by ABC Transportation can be found in Table 3-1 below, while the definition of the chemical class can be found in Table 3-2 below,

Table 3-1: List of substances handles by ABC Transportation

Substances	Chemical Class
1. Sodium hydroxide	8
2. Hydrochloric acid	8
3. Sodium hypochlorite	8
4. Liquefied chlorine	6,5.1
5. Potassium hydroxide	8
6. Potassium carbonate	8
7. Synthetic latex	N.A.
8. Vinyl acetate monomer	3
9. Butyl acetate monomer	3
10. ISO Butanol/N-Butanol	3
11. Propylene Oxide	3
12. Polyol	N.A.
13. Phosphoric acid	8
14. Nitric acid	8
15. Mono ethylene glycol	N.A.
16. Sulphuric acid	8
17. Diesel	3
18. NaOH based solutions	8
19. Acetyl Oxide	N.A.
20. Toluene/Xylene	3
21. Ketones/Alcohols	3

Table 3-2: Definitions of chemical class

Class	Definitions
1	Explosive substances and articles
2	Gases
3	Flammable liquids
4.1	Flammable solids
4.2	Substances liable to spontaneous combustion
4.3	Substances which, in contact with water emit flammable gases
5.1	Oxidising Substances
5.2	Organic peroxides
6.1	Toxic substances
6.2	Infectious substances

(Table 3-2 continued)

Class	Definitions
7	Radioactive material
8	Corrosive substances
9	Miscellaneous dangerous goods

According to Figure 1.1, ABC Transportation has 6 departments which are as follows:

- Operations Department
- Business Development Department
- Safety Department
- Administration Department
- Human Resource Department
- Accounting and Finance Department

Of all the 6 departments, only Safety department reports directly to the Managing Director. The reason of such organization structure is to provide Safety department with a special status in order to facilitate the department in enforcing new safety regulations.

3.3 Role of Safety Department and Safety Steering Committee

The Safety Department currently consists of Safety Department Manager, Safety Section Manger and a Safety Officer. The safety officer has the duty and responsibility to set up the plan, propose, implementing, auditing and evaluate on safety practices while the safety department manager and safety section manger have the duty and responsibility to review and approve safety audit plan which includes follow-up, facilitate and propose improvement guidelines in connection with the company's quality goal and objectives.

The safety department divides its activities into 2 major categories, core and supporting. The activities of each category are listed below.

Core safety activities

- Alcohol examination for pre and post delivery
- Emergency response
- Quarterly drug test

- Speed control
- Preventive maintenance for trucks and equipments

Supporting safety activities

- Vehicle inspection for pre and post delivery
- Annual health efficiency test
- Annual health examination
- Quarterly safe driving incentive

In addition to the core and supporting safety activities listed above, the safety department is also responsible for preparing various accident/incident reports. The reports are as follows.

- Accident/Incident Investigation Report
- Accident/Incident Monthly Report

The Accident/Incident Investigation and Monthly Summary Report will be presented to the Safety Steering Committee monthly meeting. The Safety Steering Committee consists of the following personnel:

- Managing Director
- Company Advisor
- Deputy Managing Director, Operations Division
- Operations Department Manager
- Human Resource Manager
- Safety Department Manager
- Safety Section Manager
- Safety Officer

The Safety Steering Committee Monthly Meeting focuses on monitoring the rate of accident/incident and the financial impacts of accident/incident to the company rather than finding ways to prevent and minimize the accident/incident.

3.4 Current Policy, Procedure and Work Instructions

ABC Transportation currently manages its safety through policy, quality procedure and work instructions. ABC Transportation integrated the safety, health and environmental policies into a single policy called Safety, Health and Environmental (SHE) Policy.

For ABC Transportation's safety related procedure and work instructions are developed based on the company SHE Policy as shown in Figure 3.2 below.

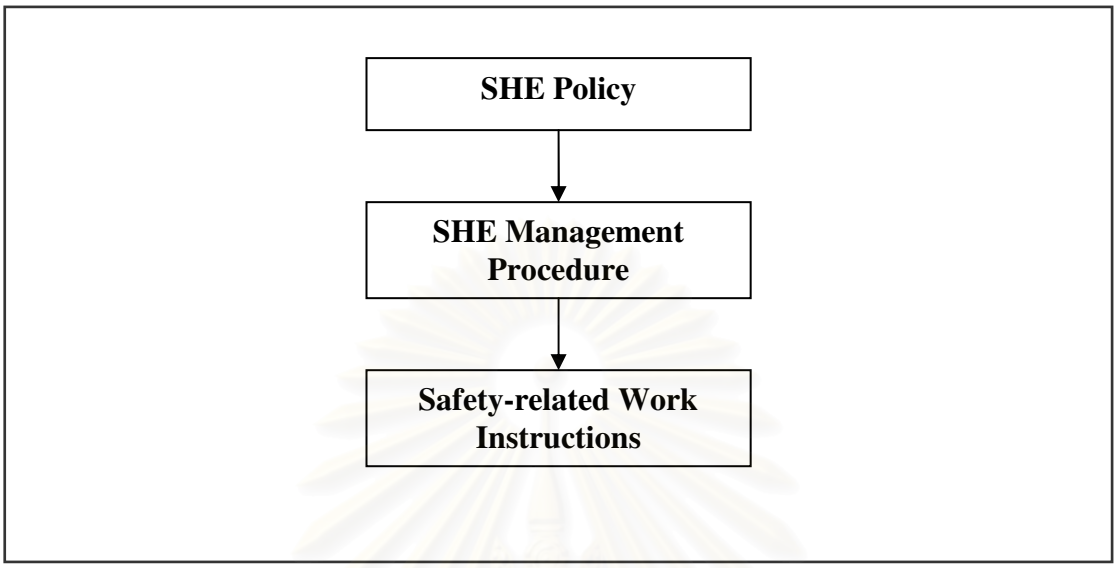


Figure 3.2: Relationship between SHE Policy, Procedure and Work Instructions

3.4.1 SHE Policy

The SHE Policy was developed in the past with the objectives of setting down the basic expectations and requirements of a good standard of practice in the hazardous substance transportation business for the purpose of ensuring the safety, protecting the health of all employees and in compliance with the Thai laws and regulations.

ABC Transportation's SHE Policy covers 6 elements which include:

- Leadership and Commitment
- Policy and Strategic objectives
- Organization, Responsibilities, Resources, Standards and Documentations
- Safety Management
- Auditing and Review

ABC Transportation's SHE Policy with full details can be found in Appendix A.

3.4.2 SHE Management Procedure

The SHE Management Procedure describes how SHE-related tasks should be accomplished. ABC Transportation's SHE Management Procedure has the following objectives,

- To promote understanding and involvement of all employees relating to SHE Management
- To ensure that all operations will be carried out successfully and safely
- To reduce loss of company's resource resulting from unsafe act and improper environmental
- To ensure safety to society and the least affect on company's asset loss and society
- To enhance all employees at all levels with knowledge and understanding to perform the correct emergency response action once the incident is taking place.
- To take immediate response action to any emergency events that might occur

ABC Transportation's SHE Management Procedure with full details can be found in Appendix B.

3.4.3 SHE-related Work Instructions

ABC Transportation currently had 9 SHE-related work instructions and 2 safety support documents. The topics of SHE-related work instructions are as follows,

- Emergency Response
- Waste and Rubbish Treatment
- First Aid Equipment
- Work Permit System
- Use of Emergency Pump
- Inspection of Data recorded from Truck Speed Recorder (TACHOGRAPH or SWG)
- Treatment of Waste Water from Cleaning of Latex Storage Tank
- Inspection of Delivery Routes, Goods Loading and Unloading Sites
- Personal Protective Equipment (PPE) Stock Control

The topics of safety support documents are as follows,

- Safety Equipments on board the Truck
- Use of Truck Speed Recorder (TACHOGRAPH)

3.5 Past Accidents/Incidents

As already mentioned in Chapter 1, for the past two years ABC Transportation experienced persistently high accidents/incidents rate in its handling and delivery process. This problem is a major concern to the management of the company, because it not only cost the company in financial aspect but also the image and the opportunity to expand its business. Of all the accidents/incidents, about 60% are avoidable accidents/incidents, and about 67% of the financial impact estimates of avoidable accidents/incidents are of major severity. Therefore the risk analysis will be focus on 12 major-severity avoidable accident/incident cases which occurred during Year 2003 and Year 2004.

The accident/incident report of the 12 cases, were translated and summarized into accident/incident (A/I) summary report which are as follows,

Table 3-3: A/I summary report - case no. PD010/2546 on 10 March 2003

Date of Accident/Incident:	10 March 2003		Case No.:	PD010/2546
Type of Accident/Incident:	Unloading Process		Dedicated Vehicle:	Yes
Location:	South Samrong, Prapadaeng, Samut Prakarn			
Detailed of Drivers Involved:	Name:	Mr. Jumlong B.	Age:	41 Years Old
	Gender:	Male	Experience:	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	12	Trailer No.:	-
	Truck Make:	HINO	Trailer Make:	-
Detailed of Accident/Incident:	Mr. Jumlong was assigned to deliver hydrochloric acid to a customer company in Samut Prakarn. After arrival at the customer company, Mr. Jumlong had followed the work instruction by climbing up the stairs adjacent to the rear end of truck's tank in order to turn a ventilation valve on top of the tank. While climbing up the stair, Mr. Jumlong slipped off from the stair and fell onto the ground, because his gloves and boots were wet and slippery. He felt a pain at his back but was tolerable; hence he continued his job until accomplished without informing his supervisor. On next day, the pain became more serious, therefore Mr. Jumlong went to consult a medical doctor. After the examination of Mr. Jumlong's back and body, the doctor prescribed medicine and advised that Mr. Jumlong should refrain from working for 2 days.			
Potential Causes:	1) The safety equipments (gloves and boots) were not in the normal conditions when in use. 2) The driver was careless for not carefully examine his safety equipments before executing his work. 3) The tank was an old designed shaped which do not have a walkway neither a rail hook for safety belt on the top of the tank to protect operator from falling down while working on tank top.			
Preventive Measures/Actions:	1) The safety department had issued an announcement to all staffs to re-check their safety equipments before start of operation and work with special care especially when working environment was not in a normal condition.			

Table 3-4: A/I summary report - case no. RY008/2546 on 16 May 2003

Date of Accident/Incident:	16 May 2003		Case No.:	RY008/2546
Type of Accident/Incident	Fatigue of driver		Dedicated Vehicle:	No
Location:	Lamae, Chumporn			
Detailed of Drivers Involved:	Name:	Mr. Padung M.	Age:	33 Years Old
	Gender:	Male	Experience:	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	B-12	Trailer No.:	HGT NO. 4
	Truck Make:	ISUZU	Trailer Make:	PANUS
Detailed of Accident/Incident:	Mr. Padung and Mr. Suthon, both drivers left the company at Rayong site at 1.00pm on 15 May 2003. They were assigned to deliver liquefied carbon dioxide to a cold storage company at Suraththani. At around 6.00am on 16 May 2003, Mr. Padung whose in charged of driving the truck at that time was approaching Klong Duad bridge, Lamae, Chumphorn, apparently he fell on sleep and lose his control caused the truck fell into the road side and overturned. The truck also collided with a tree and a fiber optic cable lamp post. Mr. Padung and Mr. Suthon were slightly injured. The two drivers informed Mr. Suthep about the incident, and were taken to Lamae Hospital by local people. Mr. Padung was later fined by the police of Baht 400 for reckless driving.			
Potential Causes:	1) Mr. Padung was fatigued from his last assignment. 2) Inappropriate assignment by supervisor – too many hours of continuous driving without enough rest for Mr. Padung			
Preventive Measures/Actions:	1) The operation manager had instructed the delivery supervisor to make sure that the assigned driver must have at least 8 hours of rest before he can start his next assignment. 2) The safety department will give a special training on “Safe Driving” for Mr. Padung and Mr. Suthon. 3) The safety department will set up a working procedure on “Pre-delivery assessment of the fitness of driver”			

Table 3-5: A/I summary report - case no. PD028/2546 on 16 June 2003

Date of Accident/Incident:	16 June 2003		Case No.:	PD028/2546
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	Yes
Location:	Suksawad Road, Bangkok			
Detailed of Drivers Involved:	Name:	Mr. Samarn P.	Age:	34 Years Old
	Gender:	Male	Experience	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	16	Trailer No.:	-
	Truck Make:	HINO	Trailer Make:	-
Detailed of Accident/Incident:	Mr. Samarn was assigned to deliver hydrochloric acid to a factory at Suksawad Road, Bangkok. After arrival at the factory about 10pm, Mr. Samarn started unloading the product through unloading hose. When unloading process was almost completed, Mr. Samarn backed off the opening of customer valve to reduce the flow, as he thought no more products was left over in the transferring hose. After backed off the customer valve, the unloading hose shook for a few times before disconnected from the connector, causing the product to spill over the surrounding area and into Mr. Samarn's eyes. During the accident, the protective eyewear was not put on, subsequently caused injuries to Mr. Samarn's eyes. Mr. Samarn gave reasons for not putting on protective eyewear because of rains and the vision was very poor, therefore putting on protective eyewear would reduce his vision at that time. Mr. Samarn had to take 5 days leaves, in order to recover his eyes.			
Potential Causes:	1) Mr. Samarn did not follow the working instruction upon unloading of chemical. 2) The unloading environmental was not good enough (not properly light up and no shelter).			
Preventive Measures/Actions:	1) Mr. Samarn will be sent to attend refreshment trainings on "Using of personal protective equipments upon working with hazardous substances" and "Delivery of hazardous substances"(WI-TR-01) 2) Deputy Operation Manager will send a formal recommendation letter to customer to improve the lighting system at unloading area for safer operations.			

Table 3-6: A/I summary report - case no. PD034/2546 on 22 August 2003

Date of Accident/Incident:	23 August 2003		Case No.:	PD034/2546
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	Yes
Location:	Bangpoo Mai, Muang, Samut Prakarn			
Detailed of Drivers Involved:	Name:	Mr. Sanae M.	Age:	31 Years Old
	Gender:	Male	Experience	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	11	Trailer No.:	-
	Truck Make:	HINO	Trailer Make:	-
Detailed of Accident/Incident:	Mr. Sanae M. was assigned to deliver sodium hydroxide to a factory in Samut Prakarn. After arrival at factory at about 9.30am, Mr. Sanae started to unload sodium hydroxide by connecting the unloading hose to customer's tank. After unloading of about 8,500 kg. Sodium hydroxide into the customer's tank, the unloading hose was slipped off from the tank's pump, caused the product spilled over on bodies of two factory staff. Mr. Sanae was watching the unloading process from nearby, rushed to the truck's rear end and switched off the pump. Fortunately, the two staffs were not sustained any injuries, and were instructed by Mr. Sanae to wash off the Sodium hydroxide from their bodies.			
Potential Causes:	1) Mr. Sanae did not inspect his equipment well enough prior started working. 2) The unloading hose coupling was not well maintained and was not fitted for using.			
Preventive Measure/Actions:	1) The Maintenance Department will inspect and replace the part that is not in good condition with new parts for all other trucks as well. 2) The operation manager arranged a meeting with customer to clarify the accident/incident and reassure with measures taken by adding an item on pre-check list for drivers to be checked prior departing the site for his new assignment.			

Table 3-7: A/I summary report - case no. PD039/2546 on 19 October 2003

Date of Accident/Incident:	19 October 2003		Case No.:	PD039/2546
Type of Accident/Incident	Road accident		Dedicated Vehicle:	No
Location:	Petchakasem Road, Cha-am, Prajuabkirikhan			
Detailed of Drivers Involved:	Name:	Mr. Songdech L.	Age:	37 Years Old
	Gender:	Male	Experience:	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	8	Trailer No.:	-
	Truck Make:	Hino	Trailer Make:	-
Detailed of Accident/Incident:	Mr. Songdech L. and Mr. Sanae were assigned to deliver liquid chlorine cylinders to a factory in Songkhla. Mr. Sanae was in charge for the 1st leg of the trip, and Mr. Songdech was driving in the 2nd leg of the trip. On the way back from Songkhla, when the truck was on Petchakasem Road, Cha-am, Prajuabkirikhan at about 4.45pm, the road condition was wet as it was raining. Mr. Songdech who was steered the wheel at that time, looked into the right mirror, and saw two buses were trying to overtake his truck on the right. Mr. Songdech did not notice a motorcycle in front of his truck on the left side, hence the truck had hit the motorcycle. The motorcyclist died instantly upon the truck was ran over the motorcycle.			
Potential Causes:	1) Mr. Songdech was not driving carefully. 2) The raining condition might have affected the driving of Mr. Songdech. 3) Fatigued of drivers due insufficient rests and relaxes over the long trip journey.			
Preventive Measures/Actions:	1) Safety rule was implemented over the long trip journey (over 5 hours) that drivers have to stop vehicle every 3 hours for relaxing over period of 15-20 minutes to prevent drivers from fatigue. 2) Parking areas are defined for long trip deliveries so that drivers can park his vehicle safely upon resting during trip journey. 3) Trips recorded will be reviewed closely to observe drivers behavior over the long trip journey.			

Table 3-8: A/I summary report - case no. PD001/2547 on 3 January 2004

Date of Accident/Incident:	3 January 2004		Case No.:	PD001/2547
Type of Accident/Incident	Unloading process		Dedicated Vehicle:	Yes
Location:	Muang, Angthong			
Detailed of Drivers Involved:	Name:	Mr. Boonsom P.	Age:	36 Years Old
	Gender:	Male	Experience	
Detailed of Vehicle Involved:	Truck No.:	B-33	Trailer No.:	LT-105
	Truck Make:	VOLVO	Trailer Make:	Rungcharoen garage
Detailed of Accident/Incident:	Mr. Boonsom P. was assigned to deliver hydrochloric acid to a factory in Angthong. After arrival at the factory at about 10.30pm, Mr. Boonsom started unloading hydrochloric acid from the truck's tank into the customer's tank. When the unloading process had been completed, while Mr. Boonsom was cleaning up his equipments, a driver of another company who was unloading the same product next to Mr. Boonsom's truck, unfortunately, the unloading hose of another transport company was slipped off from the hose connector; the product was spilled into Mr. Boonsom's eye. Mr. Boonsom was sent to a nearby hospital for medical treatment. The medical doctor prescribed him some medicine and advised that Mr. Boomsom should refrain from working for at least a week until his eyes recover completely.			
Potential Causes:	1) Mr. Boonsom had removed his protective equipment while he was staying at the unloading point after he had completed his job. 2) The driver of another transport company was careless when connecting the unloading hose.			
Preventive Measures/Actions:	1) The safety department will issue warnings to all drivers to keep distant when there is unloading of hazardous substance nearby.			

Table 3-9: A/I summary report - case no. PD009/2547 on 13 March 2004

Date of Accident/Incident:	13 March 2004		Case No.:	PD009/2547
Type of Accident/Incident	Road Accident		Dedicated Vehicle:	No
Location:	Petchakasem Road, Muang, Nakhon Pathom			
Detailed of Drivers Involved:	Name:	Mr. Thana U.	Age:	41 Years Old
	Gender:	Male	Experience	3 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	B-09	Trailer No.:	LT-136
	Truck Make:	Volvo	Trailer Make:	Sutee Group
Detailed of Accident/Incident:	Mr. Thana U. was assigned to deliver sodium hydroxide to a factory in Ratchaburi. On the way back from Ratchaburi, at about 1.30pm, while the truck was driving in the left lane on Petchakasem Road, Muang, Nakhon Pathom, there was a pick-up truck tried to overtake from the right. The pick-up truck had 1 driver and 2 passengers, successfully overtook Mr. Thana's truck. After overtaking Mr. Thana's truck, the pick-up truck moved into the left lane in front of Mr. Thana's truck. The pick-up truck suddenly jammed on the brake caused Mr. Thana who was not far behind was unable to slow down his truck, thus result in a collision. Mr. Thana's truck hit the rear end of the pick-up truck, caused minor injuries for the driver and passengers and damaged to the pick-up truck.			
Potential Causes:	1) Mr. Thana did not keep enough safety distance from the vehicle ahead from him. 2) The involved vehicle did the overtaking recklessly.			
Preventive Measures/Actions:	1) The safety department will give a special training on "Safe Driving" for Mr. Thana. 2) Driving record (tracked from truck's monitoring equipment) of Mr.Thana will be closed monitor to observe his driving behavior.			

Table 3-10: A/I summary report - case no. RY018/2547 on 23 April 2004

Date of Accident/Incident:	23 April 2004		Case No.:	RY018/2547
Type of Accident/Incident	Road Accident		Dedicated Vehicle:	No
Location:	Rama 2 Road, Samut Sakhon			
Detailed of Drivers Involved:	Name:	Mr. Manus S.	Age:	36 Years Old
	Gender:	Male	Experience:	3 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	B-01	Trailer No.:	HGT-9
	Truck Make:	Isuzu	Trailer Make:	Panus
Detailed of Accident/Incident:	Mr. Manus S. was assigned to deliver liquefied carbon dioxide to a cold storage on Rama 2 Road, Samut Sakhon. When Mr. Manus arrived at the main gate of the cold storage, he turned left into the cold storage but at the same time a motorcycle was coming from the rear on the left side of Mr. Manus's truck and heavily crashed to the prime mover. The rider of the motorcycle died instantly, while the other two passengers sustained severe injuries. Mr. Manus was not injured and was trying to help the injured parties to be sent to the hospital.			
Potential Causes:	1) The motorcyclist was riding recklessly. 2) Mr. Manus did not give a turning signal prior making a turn. 3) The entrance of the factory is not properly designed for large truck to turn in.			
Preventive Measures/Actions:	1) The safety department will give special training on "Safe Driving" for Mr. Manus.			

Table 3-11: A/I summary report - case no. PD021/2547 on 7 June 2004

Date of Accident/Incident:	7 June 2004		Case No.:	PD021/2547
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	No
Location:	At a factory in Chonburi			
Detailed of Drivers Involved:	Name:	Mr. Savoey D.	Age:	Years Old (no data)
	Gender:	Male	Experience:	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	22	Trailer No.:	LT-136
	Truck Make:	Volvo	Trailer Make:	Sutee Group
Detailed of Accident/Incident:	Mr. Savoey D. was assigned to deliver sodium hydroxide to a factory in Chonburi. After arrival at the factory at about 10am, Mr. Savoey started unloading sodium hydroxide from the truck's tank into the customer's tank, by using the unloading hose. After completion of the connection, Mr. Savoey climbed onto the truck's tank top to open the vent valve. Upon Mr. Savoey tried to get down from the tank, he accidentally injured his right foot. Mr. Savoey continued his job until completed and drove back to the company's Prapadaeng yard. On next day, Mr. Savoey went to consult a medical doctor. After the examination of Mr. Savoey's foot, the doctor concluded Mr. Savoey sustained a bone crack at his right foot, the doctor prescribed him some medicine and recommended that Mr. Savoey should refrain from working for 1 month.			
Potential Causes:	1) Mr. Savoey was not careful enough when carrying out his job. 2) The working step of climbing the tank is not proper and risky. 3) The stair was not well designed.			
Preventive Measures/Actions:	1) Mr. Savoey was instructed to be more careful upon working on tank top. 2) The stair was modified to ease climbing up safely.			

Table 3-12: A/I summary report - case no. PD030/2547 on 28 August 2004

Date of Accident/Incident:	28 August 2004		Case No.:	PD030/2547
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	Yes
Location:	At a customer factory in Angthong			
Detailed of Drivers Involved:	Name:	Mr. Narong S.	Age:	43 Years Old
	Gender:	Male	Experience:	2 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	33	Trailer No.:	LT-117
	Truck Make:	Hino	Trailer Make:	Siriprakarn garage
Detailed of Accident/Incident:	Mr. Narong S. was assigned to deliver sodium hydroxide to a factory in Angthong. After arrival at the factory at about 4pm, Mr. Narong parked the truck at the position for unloading. Mr. Narong used only the parking brake to prevent the truck from moving without using the wheel chocks. The pneumatic braking system of his truck was leaking, thus had caused the braking power of the truck to decrease and the truck started to move backwards. On realizing, Mr. Narong tried to put the wheel chocks on, but was too late, the truck hit into another truck that was parking behind Mr. Narong's truck. The accident caused damages to both trucks, fortunately there was no one injured.			
Potential Causes:	1) Mr. Narong's negligence for not following the working procedure of putting on the wheel chocks. 2) The pneumatic braking system was not in a normal condition. 3) The customer factory's parking area for unloading was not well designed.			
Preventive Measures/Actions:	1) The safety department issue an announcement to reiterate all drivers to use wheel chocks every time the truck is parked. 2) The truck was sent for inspection and repaired on the pneumatic braking system.			

Table 3-13: A/I summary report - case no. RY050/2547 on 20 October 2004

Date of Accident/Incident:	20 October 2004		Case No.:	RY050/2547
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	No
Location:	At a customer factory in Samut Prakarn			
Detailed of Drivers Involved:	Name:	Mr. Roehim T.	Age:	Years Old (no data)
	Gender:	Male	Experience:	3 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	B-16	Trailer No.:	HGT-8
	Truck Make:	Isuzu	Trailer Make:	PANUS
Detailed of Accident/Incident:	Mr. Roehim T. was assigned to deliver liquefied carbon dioxide to a factory in Samut Prakarn. After arrival at the factory at about 12.38am, Mr. Roehim was told to wait for instruction before he can unload the liquefied carbon dioxide, however Mr. Roehim did not obey, a few minutes later he started to unload liquefied carbon dioxide, by connecting the unloading hose to customer's tank. About two minutes after he started the unloading, the unloading hose was slipped off from the customer's connector, caused the unloading hose to flutter violently, the unloading hose hit several parts of the tank and the equipment stowage door. Mr. Roehim resolved the situation by rushing turned off the valve at the truck's tank. The accident caused damaged to the truck's tank, fortunately no one was injured.			
Potential Causes:	1) Mr. Roehim did not obey the instruction given by the customer. 2) Mr. Roehim did not follow the working procedure of unloading accordingly. 3) The unloading hose was not in a fit for use condition.			
Preventive Measures/Actions:	1) All of the customer's unloading hose will be inspected by ABC Transportation and the result will be sent to the customer. 2) The customer will arrange special training for all drivers responsible for delivering liquefied carbon dioxide.			

Table 3-14: A/I summary report - case no. RY057/2547 on 16 December 2004

Date of Accident/Incident:	16 December 2004		Case No.:	RY057/2547
Type of Accident/Incident	Unloading Process		Dedicated Vehicle:	No
Location:	At a customer factory in Rayong			
Detailed of Drivers Involved:	Name:	Mr. Som P.	Age:	46 Years Old
	Gender:	Male	Experience:	3 Years (driving License type 4)
Detailed of Vehicle Involved:	Truck No.:	23	Trailer No.:	-
	Truck Make:	Isuzu	Trailer Make:	-
Detailed of Accident/Incident:	Mr. Som P. was assigned to deliver sodium hypochlorite to a factory in Rayong. After arrival at the factory at about 7.00pm, Mr. Som started unloading sodium hypochlorite from the truck's tank into the customer's tank. When the unloading process was about to complete, Mr. Som disconnected the unloading hose from the customer's connector without draining the chemical that is still left in the unloading hose. After disconnected the unloading hose from the connector, the pressure within the unloading hose forced the left-over sodium hypochlorite out and spilled onto Mr. Som body. Mr. Som was taken to Bangkok-Rayong Hospital by the customer's staff for medical care. Mr. Som did not put on the protective eyewear during the unloading process resulted the product had spilled into and irritated his eyes. The medical doctor prescribed him some medicine and advised that Mr. Som should refrain from working for a few days until his eye recover completely.			
Potential Causes:	1) Mr. Som did not follow the working procedure of unloading accordingly. 2) The unloading hose was not in a fit for use condition.			
Preventive Measures/Actions:	1) Mr. Som will be sent to attend trainings on "Using of personal protective equipments upon working with hazardous substances".			

From the above 12 accident/incident summary reports, it can be observed that there are 4 major failure modes which are common or similar among the 12 cases. The 4 major failure modes are as follows,

- Road accident
- Unloading hose disconnected from connector
- Drivers fell off from tank stair/top
- Trucks not parked securely

The above 4 major failure modes of major severity avoidable accident/incident will be analyzed further through brainstorming technique along with fish bone diagram tool in the next chapter.

CHAPTER IV

Analysis

4.1 Introduction

This chapter will start off by describing the Safety Management System (SMS) working team formation. The SMS working team is needed to assist in risk analysis and provide constructive comments on the SMS requirement. The analysis in this chapter will be divided into two parts. The first part is to conduct gap analysis between the current system and the system to be developed. The second part is to study the past failure modes of major severity avoidable accident/incident cases of the case study company and to identify the potential causes, which are significant to the company safety performance and financial impacts by using risk analysis tools such as Brainstorming and Failure Modes and Effects Analysis (FMEA).

4.2 Safety Management System (SMS) Working Team

The transportation of hazardous substance business is a complex activity, and it is unlikely that one person would be thoroughly familiar with all information and knowledge required to fully understand the hazards and risks associated with the operation and business.

Therefore, consultation with a wide variety of experts is especially important in the development of risk reduction options – the more people are consulted, and the more varied their background, the more likely it is that the optimal safety management system will be developed. (Frank, et. Al., 1993)

In consideration of the above quote, a SMS Working Team is formed in order to develop SMS and conduct risk analysis of past accident/incident cases. The team would also be responsible for SHE policy and management procedure revision in the next chapter. The SMS working team comprised people knowledgeable in all aspects of the operation of ABC Transportation which includes the following representatives:

- The author – Team Leader
- Safety officer
- Senior driver
- Regulatory expert
- Maintenance engineer and/or mechanics

- Training officer
- Human resource officer

4.3 Current System Analysis

As already mentioned in section 3.4, ABC Transportation currently manages their safety through SHE policy, management procedure and work instructions. The SMS working team had discussed and suggested that in order to develop a safety management system, a standard must be chosen as reference. According to Arto Kusisto (2000), safety management system model of BS8800 (1996) represents one of the latest safety management system models, therefore the safety management system model of British Standard BS8800 (1996) was selected as a reference model.

Arto Kuusisto (2000) defined the main elements of safety management system model of the BS 8800 standard as:

1. Policy and planning
2. Organizing of activities
3. Planning an implementing of activities
4. Measuring the performance

The SMS working team conducted gap analysis between the current system and the system to be developed through a checklist as in table 4-1,

Table 4-1: Gap analysis checklist

Questions	Yes/No	Remarks
Policy and planning		
1. Does the company have a clear policy for safety? 2.1 Is it written down? 2.2 Is it up to date?	Yes Yes Yes	 Once every two years.
2. Are the employees aware of, and understand, the safety policy?	Yes	All the employees are aware of, but might not understand the safety policy truly.
3. Is safety documentation in place/appropriate/update?	Yes	Update once every two years
4. Does the company recognize safety as an integral part of business performance?	Yes	
Organizing of activities		
6. Does the company allocate responsibilities for safety to specific staff within the company?	Yes	
7. Do the safety representative (if there are any) involve in discussion of safety matters?	Yes	
8. Does the company provide sufficient information, instruction and training regarding operation procedures?	Yes	
9. Are there any safety committee within the company? If yes, what is their responsibility?	Yes	Conduct monthly safety meeting.

(Table 4-1 continued)

Questions	Yes/No	Remarks
Planning and implementation of activities		
10. Does the company have a safety plan, including objectives?	Yes	
11. Are there any systematic methods for identifying and controlling hazards?	No	
12. Are safety standards implemented?	Yes	
Measuring the performance		
13. Does the company have a proper measurement method of the implemented safety plans?	No	
14. Does the company keep records of injuries and accidents/incidents details? 13.1 Does the company analyze these records?	Yes No	
15. Does the management of the company periodically conduct follow-up of safety reports?	Yes	
16. Does the company periodically review safety performance?	Yes	
17. Does the company operate a safety audit system?	Yes	

From the checklist, the SMS working team had concluded that the current method lacks following features which are important features of an effective safety management system,

- Risk analysis process
- Closed loop system (continuous on-going process, periodically review and analyze)

4.4 Risk Analysis

The risk analysis of the past accident/incident cases done in the thesis will focus on the 12 accident/incident cases which were presented in section 3.5.

4.4.1 Brainstorming

The SMS working team brainstorms the possible root causes of 4 major failure modes which are common or similar among the 12 cases of major severity avoidable accident/incident which occurred during the period of January 2003 to December 2004. The brainstormed potential causes are classified into categories on fishbone diagrams which are as follows,

- Man
- Machine
- Process
- Substance
- Environment

The fish bone diagrams of 4 major failure modes which had been derived in chapter 3 are shown in Figure 4.1 to Figure 4.4.

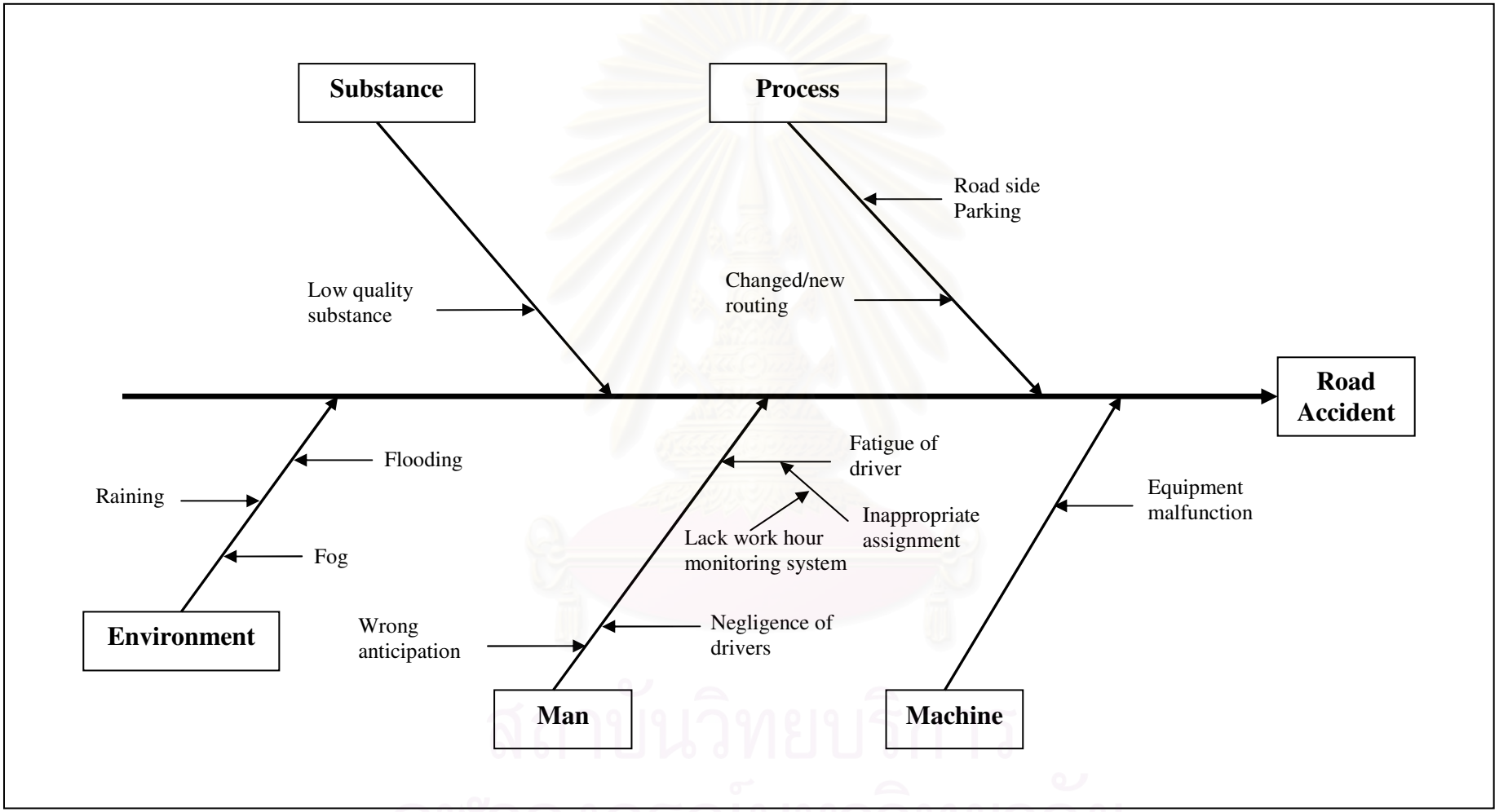


Figure 4.1: Fish Bone Diagram – Cause and Effect of Road Accident

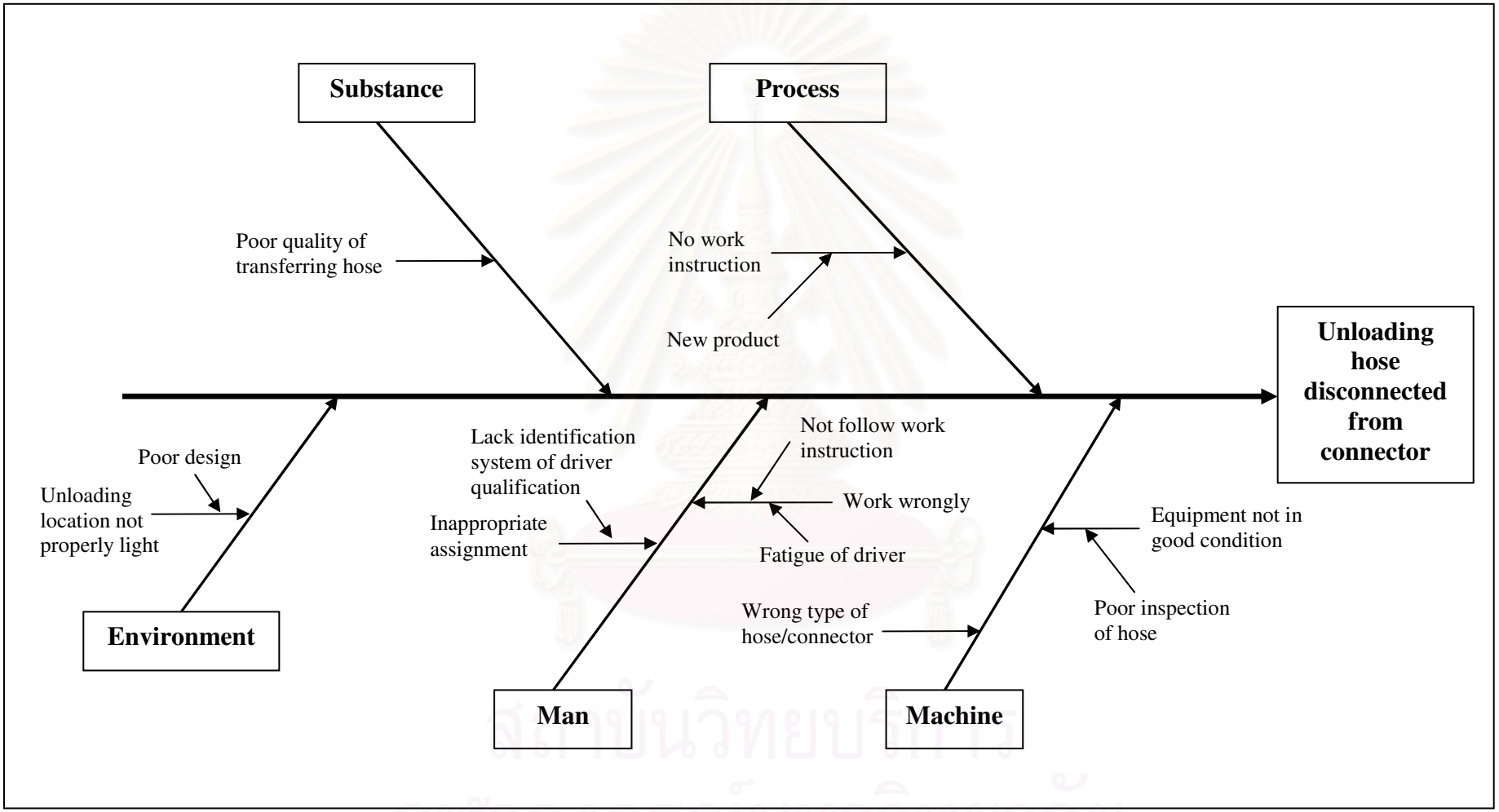


Figure 4.2: Fish Bone Diagram – Cause and Effect of Unloading hose disconnected from connector

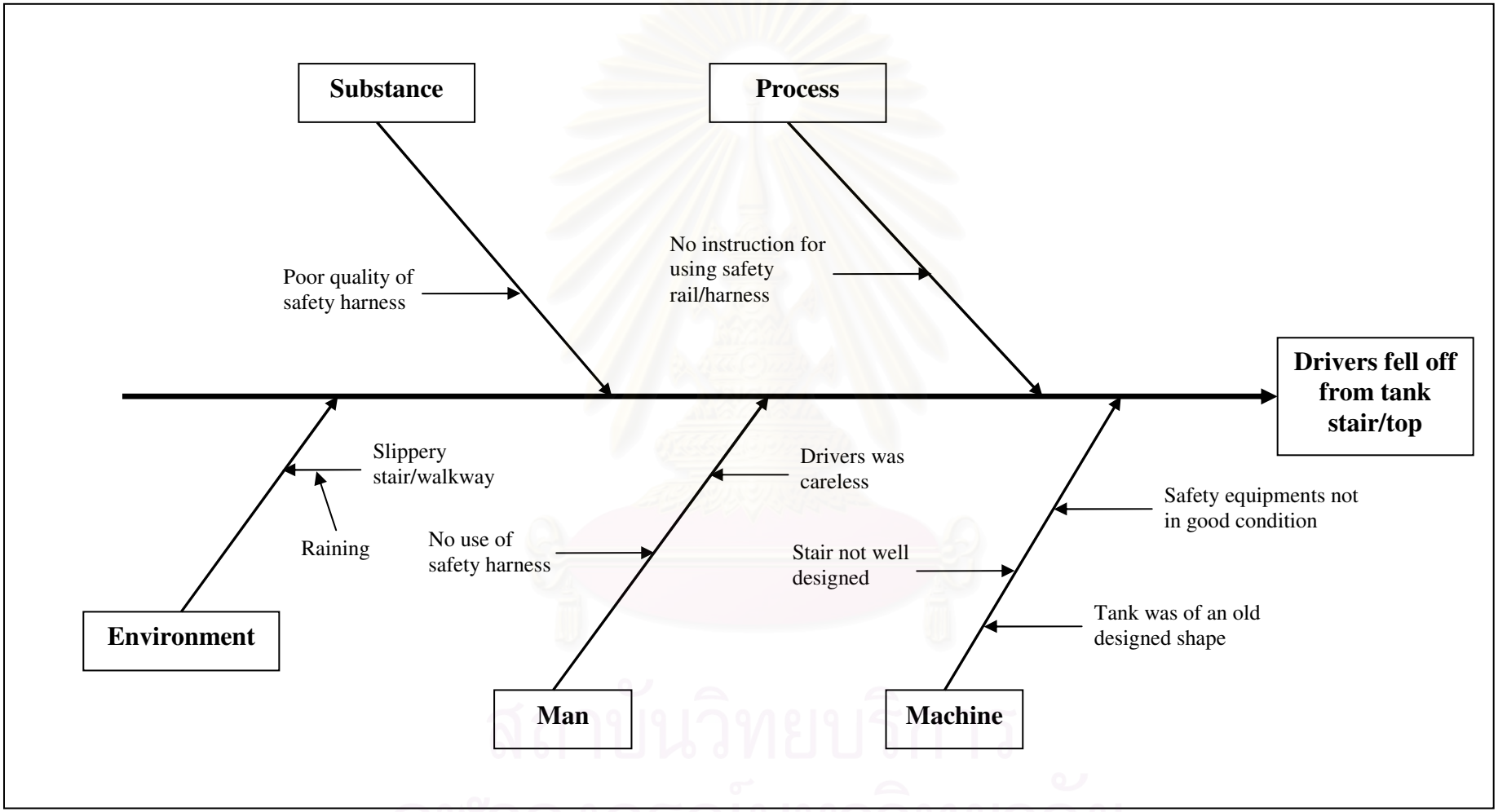


Figure 4.3: Fish Bone Diagram – Cause and Effect of Drivers fell off from tank stair/top

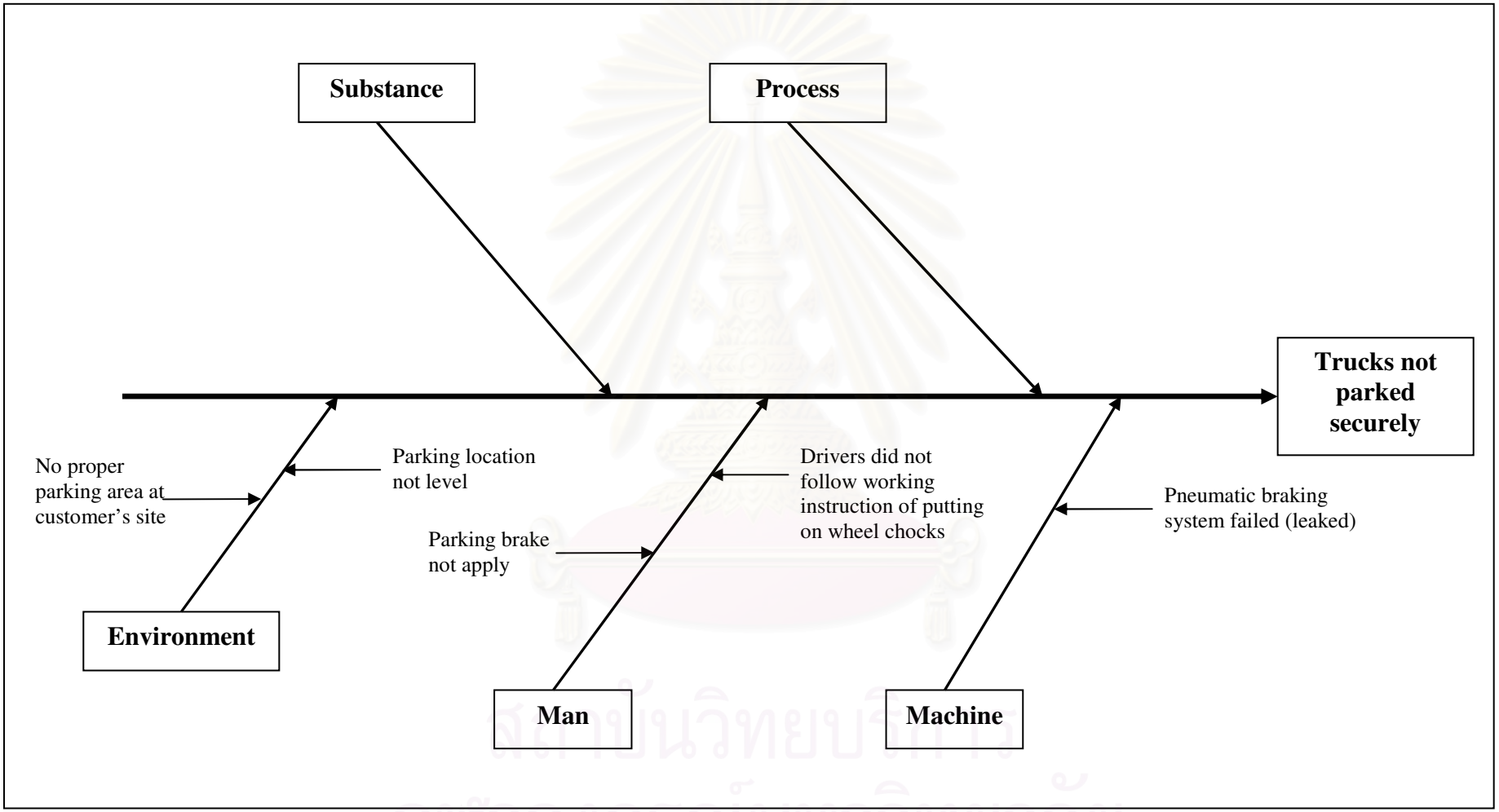


Figure 4.4: Fish Bone Diagram – Cause and Effect of Trucks not parked securely

4.4.2 Failure Mode and Effect Analysis (FMEA)

The next step is to bring 4 major failure modes and the selected 13 major potential causes as identified in fish bone diagrams into FMEA worksheet. Some of the potential causes are filtered out because the SMS working team concluded that the severity or occurrence of the potential effects and causes are not significant.

The failure modes will be worked out in order of functions or processes they are in. The level of severity, occurrence, and detection to each potential cause are rated to evaluate the risk priority. The rating criteria of the severity, occurrence and detection are according to detail described in table 2-1, 2-2, and 2-3, respectively.

Current process controls that prevent the causes of each failure mode must be identified in column 7 of the FMEA worksheet. The detection rating is evaluated according to the rating as described in table 2-3, whether the current process control are effective in preventing the process from each failure mode. The rating is noted in column 8 of the FMEA worksheet.

The significant high RPN will be taken into consideration for further solution and improvement in the safety management system. The significant high RPN is any values that are larger than the acceptable RPN. The acceptable RPN is determined by multiplying the case study company acceptable rating criteria of the severity, occurrence and detection, therefore any values that are larger than the acceptable value will be consider as high RPN.

The acceptable RPN works out as follows:

3(S) x 3(O) x 3(D) = 27

Therefore any potential causes that have RPN of 27 and above will be taken into consideration for further solution and improvement along with the proposed safety management system.

Recommended actions will be proposes to reduce or eliminate the risk associated with the failure mode. A high RPN needs the immediate attention since it indicates extreme negative effect addressed to its failure mode. The recommended actions include but should not be limited to the following; inspection, testing, monitoring, redesign, re-rating, preventative maintenance, etc. The recommended actions will be described in column 11 of the FMEA worksheet. The person in charge of each task and completion date will be noted in column 12 of the FMEA worksheet.

The expected RPN indicates whether the countermeasures are effective in reducing risk. The re-assigned scores of RPN components are written in column 13, 14, 15 and 16, respectively.

Table 4-2: FMEA Worksheet

Process FMEA (Failure Mode and Effect Analysis)

Process Name: Driving | Documented By: Kittipong | FMEA No.: RA-2005001

Core Team: Team leader, safety officer, senior driver, regulatory expert, maintenance engineer, HR officer | Responsibility: ST & OP | FMEA Date (Org): 24/08/2006 (Rev): _____ | Page: 1 of 6

Process Function and Requirement	Potential Failure Mode	Potential Effect (s) of Failure	S	Potential Cause (s) / Mechanism (s) of Failure	O	Current Process Controls	D	RPN	Ranking	Recommended Action (s)	Responsibility and Target Completion Date	Expected S	Expected O	Expected D	Expected RPN
Driving	Road accident	Driver and other road users obtained injuries, vehicles damaged or death.	5	Inappropriate assignment by supervisor – too many hours of continuous driving without enough rest	3	Driver must have at least 8 hours of rest	2	30	5	1. Implement Fatigue of Driver Management System to monitor working hours of driver	HR, ST and OP Departments November 2005	5	2	2	20
			5	Raining condition affected the visibility of drivers	2	No Control	5	50	3	1. Issue procedure to stop driving under raining or low road visibility conditions	ST and OP Departments November 2005	5	1	3	15
			5	Drivers did not keep enough safety distance from the vehicle ahead	2	No control	5	50	3	1. Defensive driving training required	HR, ST and OP Departments November 2005	4	1	5	20

Process FMEA (Failure Mode and Effect Analysis)

Process Name: Unloading | Documented By: Kittipong | FMEA No.: RA-2005001

Core Team: Team leader, safety officer, senior driver, regulatory expert, maintenance engineer, HR officer | Responsibility: ST & OP | FMEA Date (Org): 24/08/2006 (Rev): _____ | Page: 2 of 6

Process Function and Requirement	Potential Failure Mode	Potential Effect (s) of Failure	S	Potential Cause (s) / Mechanism (s) of Failure	O	Current Process Controls	D	RPN	Ranking	Recommended Action (s)	Responsibility and Target Completion Date	Expected S	Expected O	Expected D	Expected RPN
Unloading	Unloading hose disconnected from connector	Product spilled	4	Inappropriate assignment by supervisor – Lack identification system for qualification of driver	3	No Control	5	60	2	1. Implement Driver Passport System to clearly identify qualification of driver	HR, ST and OP Departments November 2005	4	2	2	16
			4	Equipments not in good condition	3	Pre-delivery checked of all equipments	2	24	7						
			4	Drivers did not follow working instruction	3	No control	5	60	2	1. Refreshment training should be considered	HR, ST and OP Departments November 2005	4	1	4	16

Process FMEA (Failure Mode and Effect Analysis)

Process Name: Unloading | Documented By: Kittipong | FMEA No.: RA-2005001

Core Team: Team leader, safety officer, senior driver, regulatory expert, maintenance engineer, HR officer | Responsibility: ST & OP | FMEA Date (Org): 24/08/2006 (Rev): _____ | Page: 3 of 6

Process Function and Requirement	Potential Failure Mode	Potential Effect (s) of Failure	S	Potential Cause (s) / Mechanism (s) of Failure	O	Current Process Controls	D	RPN	Ranking	Recommended Action (s)	Responsibility and Target Completion Date	Expected S	Expected O	Expected D	Expected RPN
			4	Unloading environment was not properly light up or no shelter	2	No control	5	40	4	1. Inform involved parties for improvement or correction	ST Department November 2005	4	1	4	16
			4	Another truck company's driver was careless	1	No control	5	20	8						
	Drivers fell off from tank's stair	Drivers obtain injuries	5	Safety equipments not in good condition	2	Procedure to re-check safety equipments before start of operation	2	20	8						

Process FMEA (Failure Mode and Effect Analysis)

Process Name: Unloading | Documented By: Kittipong | FMEA No.: RA-2005001

Core Team: Team leader, safety officer, senior driver, regulatory expert, maintenance engineer, HR officer | Responsibility: ST & OP | FMEA Date (Org): 24/08/2006 (Rev): _____ | Page: 4 of 6

Process Function and Requirement	Potential Failure Mode	Potential Effect (s) of Failure	S	Potential Cause (s) / Mechanism (s) of Failure	O	Current Process Controls	D	RPN	Ranking	Recommended Action (s)	Responsibility and Target Completion Date	Expected S	Expected O	Expected D	Expected RPN
			5	The tank was of an old designed and did not include proper safety feature	3	No control	5	75	1	1. Replaced old tank with new tank which include proper safety feature	AD, ST and OP Departments November 2005	5	1	4	20
	Trucks not parked securely	Truck moved away from parking spot and hit into other truck or object	5	Pneumatic braking system failed (leaked)	2	Pre-delivery check of truck condition.	2	20	8						
			5	Driver's negligence for not following the working procedure of putting on the wheel chocks	2	No control	5	50	3	1. Issue warnings 2. Penalty provision should be considered/ implemented	HR, ST and OP Departments November 2005	5	1	4	20

Process FMEA (Failure Mode and Effect Analysis)

Process Name: Unloading | Documented By: Kittipong | FMEA No.: RA-2005001

Core Team: Team leader, safety officer, senior driver, regulatory expert, maintenance engineer, HR officer | Responsibility: ST & OP | FMEA Date (Org): 24/08/2006 (Rev): _____ | Page: 5 of 6

Process Function and Requirement	Potential Failure Mode	Potential Effect (s) of Failure	S	Potential Cause (s) / Mechanism (s) of Failure	O	Current Process Controls	D	RPN	Ranking	Recommended Action (s)	Responsibility and Target Completion Date	Expected S	Expected O	Expected D	Expected RPN
			5	Parking space not well design	2	No control	5	50	3	1. Rearrange parking area or expanding/relocating parking area if possible	ST and OP Departments November 2005	5	1	4	20

According to the RPN ranking from table 4-1: FMEA worksheet, there are 9 sets of failures, effects and causes that are of high RPN (above 24) which are listed in table 4-3.

Table 4-3: Summary of Recommended Actions

Ranking	RPN	Failure Modes	Effects of Failure	Causes of Failure	Current Controls	Recommended Actions
1	75	Drivers fell off from tank's stair	Drivers obtain injuries	The tank was of an old designed did not have proper safety feature	No control	1. Replaced old tank with new tank which include proper safety feature
2	60	Unloading hose disconnected from connector	Product spilled	Inappropriate assignment by supervisor – Lack identification system for qualification of driver	No control	1. Implement Driver Passport System to clearly identify qualification of driver
2	60	Unloading hose disconnected from connector	Product spilled	Drivers did not follow work instruction	No control	1. Refreshment training should be considered
3	50	Road accident	Driver and other road users obtained injuries, vehicles damaged or death.	Raining condition affected the visibility of drivers	No control	1. Issue procedure to stop driving under raining or low visibility conditions

Table 4-2: Continued

Ranking	RPN	Failures Mode	Effects of Failure	Causes of Failure	Current Controls	Recommended Actions
3	50	Road accident	Driver and other road users obtained injuries, vehicles damaged or death.	Drivers did not keep enough safety distance from the vehicle ahead	No control	1. Defensive driving training required
3	50	Trucks not parked securely	Truck moved away from parking spot and hit into other truck or object	Driver's negligence for not following the working procedure of putting on the wheel chocks	No control	1. Issue warnings 2. Penalty provision should be considered/ implemented
3	50	Trucks not parked securely	Truck moved away from parking spot and hit into other truck or object	Parking space not well design	No control	1. Rearrange parking area or expanding/relocating parking area if possible
4	40	Unloading hose disconnected from connector	Product spilled	Unloading environment was not properly light up or no shelter	No control	1. Inform involved parties for improvement or correction of the unloading location environment
5	30	Road accident	Driver and other road users obtained injuries, vehicles damaged or death.	Inappropriate assignment by supervisor – too many hours of continuous driving without enough rest	Driver must have at least 8 hours of rest	1. Implement Fatigue of Driver Management to monitor working hours of driver

In addition to the above failures, another difficulty in reducing the high rate of accident/incident and recurring accident/incident according to the safety officer, lies in the accidents/incidents investigation and analysis process. The safety officer commented that in addition to the identification of the immediate cause, the real root cause of the accident/incident should also be ascertain, in order to identify the effective recommended actions to prevent a recurrence of similar events. Therefore, the SMS working team would like to propose that an Accidents/Incidents Investigation and Analysis system to be added to the current policy and procedures.

CHAPTER V
Proposed SMS, Recommended Actions and Implementation Results

5.1 Introduction

In this chapter, the SMS working team would propose SMS and revised SHE policy and procedures based on the analysis result of the previous chapter. The SMS and SHE policy and procedures proposed in this thesis will be based on international regulations and recommendations and the Thai regulations and recommendations on safe management practices. The proposed SMS, SHE policy and procedures are developed and modified for the purpose of ensuring the safety, and protecting the health and welfare of persons employed in the case study company.

5.2 Proposed Safety Management System

From section 4.3, the analysis showed that the current system lacks risk analysis and the system is not a closed loop (continuous on-going process). In order to create a successful SMS, the SMS working team integrated these two elements to the current system and creates the proposed SMS. The process flow of the proposed SMS is shown in Figure 5.1.

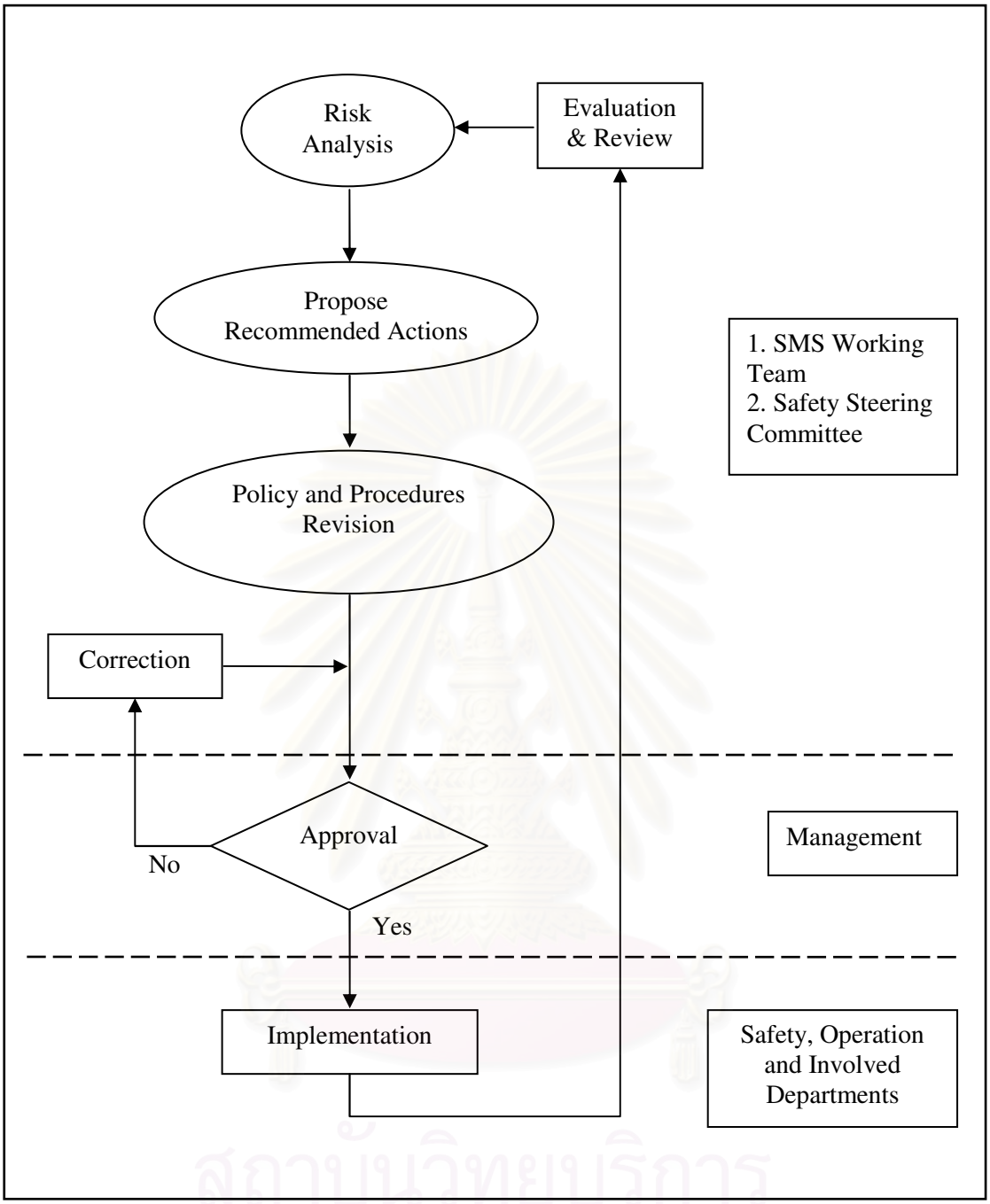


Figure 5.1: Proposed Safety Management System Process Flow

SMS should be regarded as a continuous process. The process should be repeated at regular intervals such as monthly or quarterly basis, based on practical experience and accident/incident evaluation. A review of risk analysis should also be carried out each time there is a significant change in the operational activities (e.g. handling of new products, use of new equipment, changes in operating procedures).

Many of the process of proposed SMS shown in Figure 5.1, are best implemented using a multi-disciplinary team. In particular, SHE policy, procedures revision and development are best implemented as team activities, therefore the SMS

working team will be responsible for risk analysis, propose recommended actions, policy and procedures revision. The risk analysis process would be based on FMEA technique by analyzing the past accident/incident cases. The policy, procedures and work instructions will be revised according to the recommended actions of FMEA process.

The case study company management will be responsible for approving the revised policy, procedures and work instructions proposed by SMS working team. Once the SHE policy, procedures and work instructions are approved by the management, the Safety Department, Operation Department and other involved department will then be responsible for the implementation of the revised policy, procedures and work instructions.

The Safety Steering Committee (SSC) mentioned and described in section 3.3, which had already been in place will be responsible for monthly evaluation and review of new accident/incident cases which occur in a past month and also took over the responsibility which was responsible by the SMS working team. Therefore the safety management system process will continue and repeat in a loop manner.

In order to implement SMS, the current SHE policy is revised by adding a sub-element to the “Safety Management” element, while the SMS procedure is drawn up and added to the current SHE Management Procedure.

5.2.1 Proposed Safety Management System Policy

Safety Management System is a system to identify, analyze and update all existing risks of on-going delivery operations and to reduce occurrence probability and mitigate the consequences of safety accidents/incidents through comprehensive risk analysis tools. Essential information about the risk is adequately gathered and used for decision making. Proposed recommended actions are effectively carried out by the area owner under sufficient management control to make sure that the acceptable risk level is eventually achieved.

5.2.2 Proposed Safety Management System Procedure

1. Objective

To identify, analyze and update all existing risks of on-going delivery operations and to reduce occurrence probability and mitigate the consequences of safety accidents/incidents through comprehensive risk analysis tools.

2. Scope

The system covers safety management for existing facilities and on-going delivery operations.

3. Definitions

3.1 Safety Steering Committee (SSC) comprised of

- Managing Director
- Company Advisor
- Deputy Managing Director, Operations Division
- Operations Department Manager
- Human Resource Manager
- Safety Department Manager
- Safety Section Manager
- Safety Officer

3.2 Accident/Incident Report refers to report of an accident/incident to be issued by Safety Department Manager within 1 week after initial accident/incident.

3.3 Accident/Incident Investigation Report refers to report of the accident/incident investigation to be issued by investigation committee, when the accident/incident is of major or very major severity.

4. Responsibilities

4.1 The Safety Steering Committee (SSC) will be the system owner, whose responsibilities are to:

- maintain the SMS
- inform the managing director of all new higher risks

4.2 The Safety Officer is responsible for brining all accident/incident reports and accident/incident investigation reports to the upcoming SSC monthly review

5. Procedures

5.1 The SSC conducts a monthly review of the accident/incident report and investigation report to identify preventive and mitigative measures.

5.2 Any accident/incident, defined as major or very major severity, shall be reviewed by SSC annually to ensure that preventive and mitigative measures are effectively implemented and well followed up.

5.3 The identified major or very major severity accident/incident cases are regularly used as topics for emergency drills and simulation for familiarity and continuous improvement in dealing with the scenarios. Result from the emergency drills / simulation shall be used to improve mitigative measures of the scenario if applicable.

5.4 The safety officer is responsible for bringing all accident/incident reports and investigation reports to the upcoming SSC monthly review.

5.5 Each accident/incident report is reviewed and endorsed by the SSC. Modifications on each proposed recommended action and preventive measure are permitted and must be documented on the FMEA Worksheet. Each endorsed recommended action and preventive measure is returned to the line manager for execution.

5.6 After endorsed recommended action and preventive measure are returned to the line manager, the line manager has to communicate the action and measure to appropriate people in both his own and related areas to strengthen the awareness of the discovered risks.

5.7 The line manager will prioritize the endorsed action plans based on the criticality of the risks. The action plan of high risk must be executed immediately. For low risk, action plans will be executed based on availability of resources. The line manger is responsible for initiating, implementing and evaluating of all action plans under supervision.

5.3 Recommended Actions

From the analysis conducted in chapter 4, the recommended actions were given in order to reduce accident/incident rate and prevent recurrence of similar events; therefore this section will go through each of the recommended actions in details, by the order of high to low RPNs except those that do not required changes in the policy and procedures will be group together and listed in section 5.3.5, while accident/incident investigation and analysis which was proposed by the SMS working team to be added to the current policy and procedures will be in section 5.3.6.

5.3.1 Driver Passport System

The driver passport system will be added to the "Safety Management" element of the current ABC Transportation SHE Policy, which can be found in Appendix A.

5.3.1.1 Proposed Driver Passport System Policy

The Driver Passport System is an accreditation system to give clear identification of the drivers' skill and competency. The driver passport is a document which is a key element in ensuring the dispatcher personnel and the customer that assigned drivers are fully competent to carry out his task. The driver passport will have the following details,

5.3.1.2 Proposed Driver Passport System Procedure

1. Objective

To provide a system to clearly identify the drivers' skill and competency to assist in ensuring the dispatcher personnel and the customer that assigned drivers are fully competent to carry out his task.

2. Scope

The driver passport system shall cover all drivers of ABC Transportation. The driver passport system covers in house training and customer specific training certification.

3. Definitions

3.1 Driver passport refers to a booklet to be carry at all time by the driver when carrying out any operation. The passport shall contain the following information,

- Recent photograph of the driver (not more than 6 months old)
- Name and personal details of the driver (age, height, weight and etc.)
- No. of years working with the company
- Validity of driving license and class obtained
- Training undergone and test passed (where testing is applicable)
  - Annual Physical examination
  - Basic knowledge of hazardous substance
  - Use of personal protective equipments
  - Loading/unloading of specific products
  - Customer specific training

3.2 Training certification refers to the approval of certification of driver who had successfully undergone training.

4. Responsibilities

4.1 All drivers are responsible for carrying driver passport with him/her at all time when carrying out his/her tasks and present his/her driver passport when request by the dispatcher personnel, customer or

4.2 Human Resource department is responsible for issuance, update, renew and record keeping of all the driver passports.

5. Procedures

5.1 When a driver is employed, the Human Resource department will immediately issue a driver passport for him/her.

5.2 Each time a driver passport holder has undergone and successfully pass any training course, the passport holder will be given a stamp to certify that he/she had undergone and successfully pass the training course.

5.3 Each time a driver obtained a new stamp, he/she must present the passport to the HR department, so that the HR department can update the records of his/her driving passport onto the department record book.

5.4 Whenever requested by the supervisor, dispatcher or customer for the examination of the passport, the driver must surrender his/her passport to the above mentioned personnel.

6. Related Documents

6.1 Driver Passport (see example in figure 5.2)

Figure 5.2: Example of driver passport

5.3.2 Training System

Training which was previously a sub-element in the current SHE policy, shall be added to the current SHE policy as an element on its own. This is because the SMS working team felt that there is a need of a training system to be in place and to give more importance to training.

5.3.2.1 Proposed Training System Policy

To equip employees at all levels with the knowledge, skills and attitudes relating to the operation or maintenance of facilities so as to work in a safe and reliable manner. An effective training program shall be established to ensure that the training needs of

all employees are identified and satisfied in an appropriate and adequate manner so that all operations are carried out safely and with proper regard for environmental protection.

5.3.2.2 Proposed Training System Procedure

1. Objective

To equip employees at all levels with the knowledge, skills and attitudes relating to the operation or maintenance of facilities so as to work in a safe and reliable manner.

2. Scope

The training procedure is for all ABC Transportation employees only.

3. Definitions

3.1 "Training according to the annual training schedule" refers to the trainings that had been planned and proposed by the departments in advance, which can be conducted within the company premises or not.

3.2 "Training not according to the annual training schedule" refers to the trainings that are requested by the departments and not included in the annual training schedule.

3.3 "On the Job Training (OJT)" refers to internal trainings of any departments/sections conducted by the supervisor.

4. Responsibilities

4.1 The managing director is responsible for specifying and maintaining the guideline of this procedure.

4.2 Related department manager and/or related section are responsible for proposing training requirement of their staffs.

4.3 HR department manager is responsible for compiling all the training requirements and propose annual training schedule for approval and maintenance of the training system

4.4 HR department officer is responsible for carrying out according to this procedure.

5. Procedures

5.1 Human Resource (HR) Department conducts annual survey on employee training requirement by asking all the employees to fill

in the survey form. The survey form has to be return to HR department by the end of October every year.

5.2 HR department accumulate all the surveys and assess the training requirement of all employees. After the assessment, the Annual Training Schedule shall be drafted accordingly and send to the managing director for approval by the end of December every year.

5.3 The managing director may or may not approve the annual training schedule proposed by the HR department. In the case that the schedule is disapproved by the managing director, the HR department must revise the schedule again until the managing director approve the schedule.

5.4 **a) Training according to the annual training schedule**

Prior to the each training class, the HR department will send out Training Attendance Confirmation Form to all the departments, in order to get confirmation from the attendants and organize the day for training class to be held by using Training Approval Form. The training approval form will be send to the managing director for approval.

b) Training not according to the annual training schedule

In the case that any of the department would like to organize a training class in addition to the annual training schedule, the department will need to fill in the Training Approval Form and send to the managing director for approval.

5.5 The managing director may or may not give approval to the training approval form proposed by the HR department or any other department. In the case of disapproval, the training class shall be cancel.

5.6 After approval from the managing director, the HR department coordinates with the department that requested for training to organize the training class.

5.7 After the completion of each training class, the attendants or trainees will be evaluated by the line supervisor or HR department or trainer. The evaluation can be done by using Training Evaluation

Form. In the case of fail, the attendants or trainees will be resend for training again until he/she passed the evaluation.

5.8 The HR department record down the training record of all the employees that had attended training class.

5.9 In the case that the line supervisor feels the need of conducting an OJT due to employment of new employee, change in operation procedure, new equipments are introduced for operation. The line supervisor can conduct the OJT and use the Training Evaluation Form to evaluate the attendants.

6. Related Documents

6.1 Annual Training Schedule (see example in figure 5.3)

6.2 Training Approval Form (see example in figure 5.4)

6.3 Training Evaluation Form (see example in figure 5.5)

6.4 Employee Training Record (see example in figure 5.6)

6.5 Training Attendance Confirmation Form (see example in figure 5.7)

ABC Transportation Co., Ltd.

Annual Training Schedule

Year ..... Page.....

No.	Training Date	Training Topic	Objective	No. of Attendants	Position	Arranged By	Remark

Proposed by Training Section/HR Deapartment

.....

.....

.....

( )

Position.....

...../...../.....

Managing Director Approval :

☐ Approve

☐ Disapprove

☐ Others.....

.....

( )

...../...../.....

Figure 5.3: Example of annual training schedule form

ABC Transportation Co., Ltd.

Training Approval Form	Date……

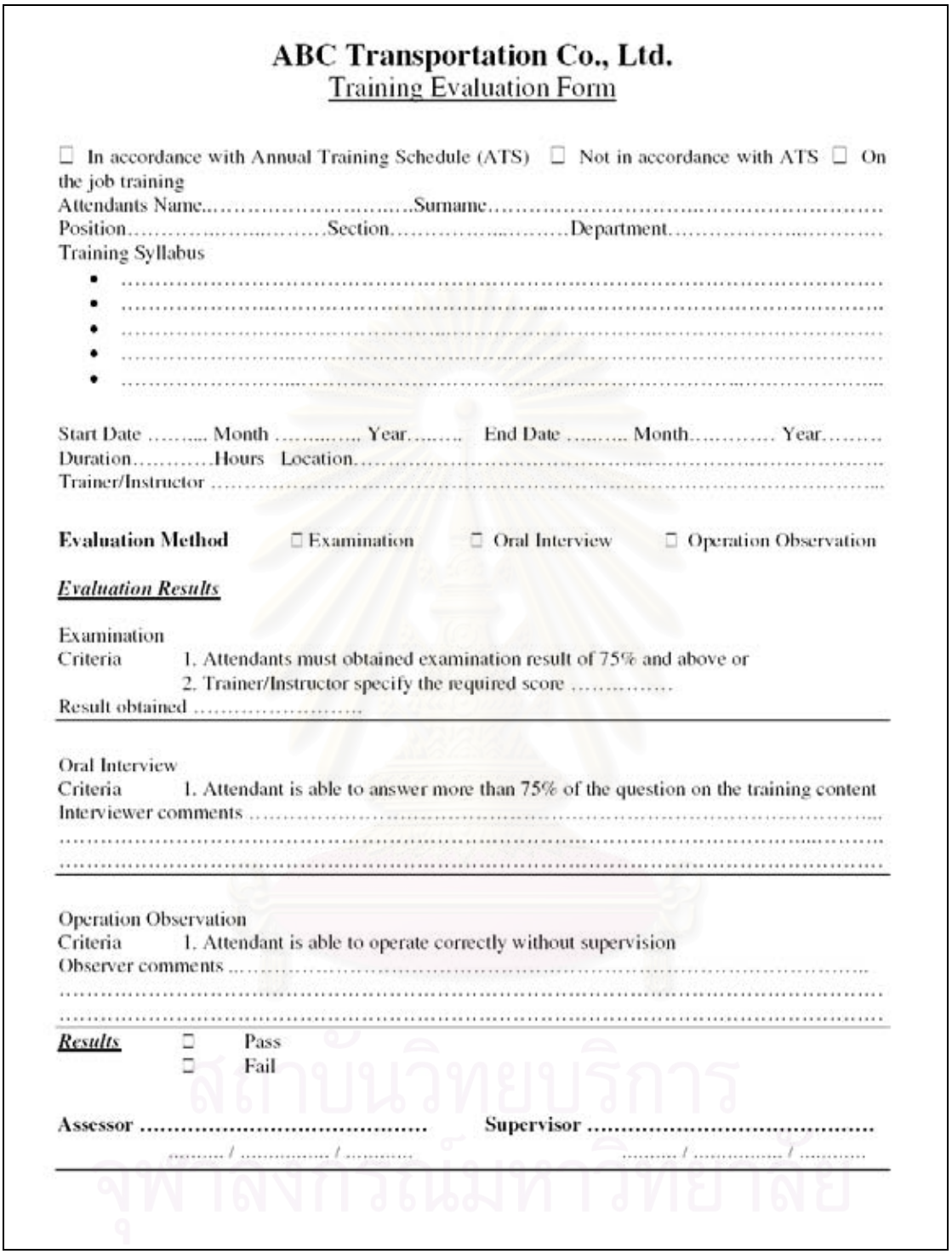
☐ In accordance with Annual Training Schedule (ATS) ☐ Not in accordance with ATS

Section……..Department……

- Objective……
  ……
- No. of attendants……
- Training period……...Start of training date……
- Training Topic/Syllabus……
- Trainer/Speaker……
- Training Location……
- Recommendations……
  ……

Propose by	Inspect by	Approve by
……	Comments…… …… …… …… ……	☐ Approve ☐ Disapprove Comments…… …… ……
( )	……	……
Position……	( )	( )
……/……/……	……/……/……	……/……/……

Figure 5.4: Example of training approval form



ABC Transportation Co., Ltd.

Training Evaluation Form

☐ In accordance with Annual Training Schedule (ATS) ☐ Not in accordance with ATS ☐ On the job training

Attendants Name……Surname……

Position……Section……Department……

Training Syllabus

- ……
- ……
- ……
- ……
- ……

Start Date …….... Month ……..…. Year…..…. End Date ……... Month……. Year……

Duration……Hours Location……

Trainer/Instructor ……

Evaluation Method ☐ Examination ☐ Oral Interview ☐ Operation Observation

Evaluation Results

Examination

Criteria 1. Attendants must obtained examination result of 75% and above or

2. Trainer/Instructor specify the required score ……

Result obtained ……

Oral Interview

Criteria 1. Attendant is able to answer more than 75% of the question on the training content

Interviewer comments ……

……

……

Operation Observation

Criteria 1. Attendant is able to operate correctly without supervision

Observer comments ……

……

……

Results ☐ Pass

☐ Fail

Assessor …… **Supervisor** ……

……/……/…… ……/……/……

Figure 5.5: Example of training evaluation form

ABC Transportation Co., Ltd.
Employee Training Record

Name..... Position..... Section..... Department.....

Training Date	Training Topic	Arranged By	Trainer/ Instructor	Evaluation	Remark

Figure 5.6: Example of employee training record form

ABC Transportation Co., Ltd.
Training Attendance Confirmation Form

Syllabus.....

Date.....

Location.....

Date……Month……..…Year……

…….. Department would like to confirm that the following ……officers will be attending the above mentioned syllabus

1)…….. Position…..
2)…….. Position…..
3)…….. Position…..
4)…….. Position…..
5)…….. Position…..
6)…….. Position…..
7)…….. Position…..
8)…….. Position…..
9)…….. Position…..
10)…….. Position…..

Remark : If the number of officers attending the training exceed 10, please attached the name list to this form

.....
( )
Position.....

Figure 5.7: Example of training attendance confirmation form

5.3.3 Procedure for driving in a raining condition

The procedure shall be added to ABC Transportation current procedure for transportation process, which can be found in Appendix C. The phrases to be added to the procedure are as follows,

1. The dispatcher, safety officer or operation supervisor have to assess the visibility condition of the environment and make sure that the visibility is not less than 50meters before authorizing any delivery trip.
2. When driving and road visibility is reduced to less than 50 meters, the driver must stop the vehicle and contact the Operations Department Manager, to ask for a suspension of duty until the road visibility is more than 50 meters.

5.3.4 Fatigue of Driver Management

The fatigue of driver management will be added to the current ABC Transportation current SHE Policy, under the “Safety Management” element and the procedure shall be added to ABC Transportation current procedure for transportation process, which can be found in Appendix C.

5.3.4.1 Proposed Fatigue of Driver Management Policy

Fatigue is a major safety hazard for tank truck drivers. Crashes due to fatigue tend to be severe with little or no braking or avoidance action. The risk of death or serious injury to the driver and to the occupants of other vehicles is very high. Fatigue is the primary cause of long distance large vehicle accidents. For these reasons, ABC Transportation restricts the number of hours that a driver is allowed to drive. More importantly, management and staff who supervise drivers must not allocate work to a driver which may reasonably be expected to involve longer driving periods than allowed. The allowable driving hours shall be based on international standards and Thai regulations, whichever is more stringent will take precedence.

5.3.4.2 Proposed Fatigue of Driver Management Procedure

The phrases to be added to the procedure are as follows,

1. The dispatcher have to assess the working hours of the driver to make sure that the driver had enough rest and the working hours did not exceed the following restrictions before authorizing the driver to carry out the delivery operation.
    - **12 hours in any 24 hour period**. After 12 hours of driving duties, or 14 hours of overall work-time, whichever occurs first, a driver must have a continuous break of at least 8 hours.
    - **72 hours of driving or work-time in any 7 day period**. The only exceptions to these provisions are in emergencies to allow a driver to return to base or a suitable rest place.
2. The safety officer shall assess the driving hours of the driver through TACHOGRAPH and Delivery Operation Trip Reporting Form after each delivery operation to make sure that the driver after 5.5 hour period of continuous driving, the driver must have a break of at least 30 minutes. And during any prolonged period of driving, drivers are advised to also take a mini-break of at least five minutes every two to three hours to stretch, walk around their vehicle, and check the security of the vehicle and the goods.

5.3.5 Recommended Actions that do not required changes to Policy and Procedures

There are 4 recommended actions which were carried out by the area owner and did not required changes to the current policy and procedure. The 5 recommended actions are as follows,

1. Replace old tanks with new tanks
2. Issue warnings
3. Penalty provision should be considered/ implemented
4. Rearrange parking area or expanding/relocating parking area if possible
5. Inform involved parties for improvement or correction of the unloading location environment

5.3.6 Accident/Incident Investigation and Analysis

Accident/incident investigation and analysis shall be added to the current SHE policy as an element on its own. Even though this is not derived from the FMEA study, but the SMS working team felt that there is a need of accident/incident investigation and analysis system to be in place because with an accurate determination of root cause, only then effective recommended actions can be identified.

5.3.6.1 Proposed Accident/Incident Investigation and Analysis Policy

To establish procedures for accident/incident reporting and investigation so as to identify root causes of accidents/incidents and to recommend and implement effective corrective measures or systems to prevent recurrence of similar accident/incident.

5.3.6.2 Proposed Accident/Incident Investigation and Analysis Procedure

1. Objective

To provide a system to report and analyze accidents/incidents to ensure effective accident/incident investigation, reporting and follow-up. Information from reported accidents/incidents will be periodically reviewed to identify improvements and share lessons learned from accidents/incidents among ABC Transportation organizations to prevent recurrence.

2. Scope

The Accident/Incident Investigation and Analysis system shall cover all job related accidents/incidents involving employees or activities supervised, owned or controlled by ABC Transportation. Types of accident/incident include injuries, fire/explosion, hazardous substance spill, loading incident, environmental release, damage to equipment, vehicle accident and product contamination. The system also covers job related illness, third party liability and incidents from natural disaster, security violation.

3. Definitions

3.1 Accident/Incident Report refers to report of an accident/incident to be issued by Safety Department Manager within 1 week after initial accident/incident.

3.2 Accident/Incident Investigation Report refers to report of the accident/incident investigation to be issued by investigation committee, when the accident/incident is of major or very major severity.

3.3 Investigation Committee refers to a team established by Managing Director or respective Deputy Managing Director to analyze and to determine causes and recommendations of the major or very major severity accident/incident.

3.4 Investigation Team refers to a team initially assigned by the immediate supervisor for an accident/incident reporting.

4. Responsibilities

4.1 All employees are responsible for reporting an accident/incident to their immediate supervisor or safety officer immediately. The Accident/Incident Report Form.

4.2 Safety Department Manager is responsible to select the accident/incident reports for SSC review based on its severity, potential of being severed, and the learning value of the report itself.

4.3 Investigation Committee is responsible to identify root causes and contributing factors to the accident/incident, and recommends actions needed to reduce the risk of this and related accident/incident. The investigation report must be sent to the Safety Department Manager within 1 month after initial accident/incident to further process for SSC review.

5. Procedures

5.1 When an accident/incident is reported, the immediate supervisor will assign an “Investigation Team” consisting of persons having hand-on experience on the work involved in the accident/incident. At least one member of the team must be trained on Why Tree Method, Fish Bone Diagram or Root Cause Analysis

5.2 The immediate supervisor will be responsible to secure evidence for root causes and contributing factors of the accident/incident to

be used by the assigned Investigation Team to prepare the accident/incident report.

5.3 The line manager will review the report prior to pass on to safety officer for SSC review.

5.4 If the accident/incident is of major or very major severity, Managing Director or respective Deputy Managing Director will establish an Investigation Committee within 24 hrs of the initial accident/incident. At least one member of the Investigation Committee will be properly trained on the Why Tree Method and Root Cause Analysis.

5.5 If there is an indication that any person involved in the accident/incident is under influence of Alcohol or Drugs, the Safety Department Manager or line function Section Manager or the Management will determine if medical evaluation or alcohol and drug testing is required in the investigation.

5.6 The accident/incident report must be issued by line function Section Manager within 1 week after initial accident/incident and sent to Safety Officer.

5.7 All accident/incident will be reported in the SSC Monthly Meeting.

5.4 Implementation Results

This section would investigate into the result of the post implementation period of SMS, revised SHE Policy, SHE Management Procedure and Work Instructions. The comparison will be done in 2 main parts, first comparison is of pre and post implementation accident/incident rate, second comparison is pre and post implementation financial impacts estimates of avoidable accident/incident. Due to the time constraint, the post implementation result will only be of 3 months period which are December 2005, January 2006 and February 2006. For consistency reason, the classification of the severity in the accident/incident cases during the implementation period will be the same as in Chapter 1, again this will not have any impact on the values or interpretation of the implementation result.

5.4.1 Accident/Incident Rate Comparison

Table 5-1 compares accident/incident rate of pre and post implementation results.

Type of Accidents/Incidents (A/I)		1st Quarter 2004	2nd Quarter 2004	3rd Quarter 2004	4th Quarter 2004	Total	Average	Dec 2005 - Feb 2006
1. Minor	Avoidable A/I	12	4	10	5	31	7.75	3
	Unavoidable A/I	3	11	3	6	23	5.75	3
2. Medium	Avoidable A/I	4	4	7	7	22	5.5	4
	Unavoidable A/I	5	4	4	4	17	4.25	2
3. Major	Avoidable A/I	1	2	1	3	7	1.75	1
	Unavoidable A/I	1	0	3	0	4	1	0
Total Avoidable A/I		17	10	18	15	60	15	8
Total Unavoidable A/I		9	15	10	10	44	11	5
Total A/I		26	25	28	25	104	26	13

Table 5-1: Accidents/Incidents rate comparison between the quarters of Year 2004 and December 2005 to February 2006 period

From table 5-1, it can be observed that there is only 1 case of major severity avoidable accident/incident during the implementation period which is equal to or less than any quarter in 2004 and the average of 2004. In addition, the accident/incident cases of other types and severities are equal to or less than any quarter in 2004 and the average of 2004 as well.

Taking into account the seasonal effect, which might affected the result of the implementation. The author would like to further compare the implementation result

with the past record, by comparing the result of implementation period to the results of the same calendar period which are December 2003 - February 2004 and December 2004 - February 2005. This comparison is illustrated in table 5-2 below.

Type of Accidents/Incidents (A/I)		Dec 2003 - Feb 2004	Dec 2004 - Feb 2005	Dec 2005 - Feb 2006
1. Minor	Avoidable A/I	9	1	3
	Unavoidable A/I	1	4	3
2. Medium	Avoidable A/I	5	7	4
	Unavoidable A/I	6	4	2
3. Major	Avoidable A/I	1	2	1
	Unavoidable A/I	1	0	0
Total Avoidable A/I		15	10	8
Total Unavoidable A/I		8	8	5
Total A/I		23	18	13

Table 5-2: Accidents/Incidents Rate Comparison for the same calendar period

Again from table 5-2, it can be observed that there is only 1 case of major severity avoidable accident/incident during implementation period which is equal to or less than two predecessor periods of the same calendar period. However, the results are not in line for accident/incident cases of other types and severities.

5.4.2 Accident/Incident Financial Impact Comparison

Table 5-3 compares accident/incident financial impact estimates of pre and post implementation results.

Period / Severity	1st Quarter 2004	2nd Quarter 2004	3rd Quarter 2004	4th Quarter 2004	Total (THB)	Average (THB)	Average (THB/1,000,000 KM)	Dec 2005 - Feb 2006	Dec 2005 - Feb 2006 (THB/1,000,000 KM)
Minor	32,160	6,000	24,360	20,000	82,520	20,630	10,820.18	7,600	4,175.50
Medium	163,448	70,000	136,700	84,000	454,148	113,537	59,548.73	86,500	47,523.74
Major	308,000	416,000	46,000	290,000	1,060,000	265,000	138,989.18	109,000	59,885.40
Total	503,608	492,000	207,060	394,000	1,596,668	399,167	209,358	203,100	111,585

Table 5-3: Accidents/Incidents financial impact estimates comparison between the quarters of Year 2004 and December 2005 to February 2006 period

CHAPTER VI

Conclusion and Recommendations

6.1 Conclusion

The purpose of this research is to develop a Safety Management System (SMS) for hazardous substance transportation based-on risk analysis to reduce the rate and financial impacts of major severity avoidable accidents/incidents of the case study company. The risk analysis methods used in this research is FMEA.

A Safety Management System (SMS) working team is formed in order to develop SMS and conduct risk analysis of past accident/incident cases. The team would also be responsible for SHE policy and procedures revision.

Primarily, the SMS working team chose the safety management system model of British Standard BS 8800 (1996) as a reference model. The SMS working team then conducted a gap analysis between the current system and the safety management system model of BS 8800 (1996), using checklist to determine the additional requirement to the current system. From the checklist, the SMS working team had concluded that the current method lacks following features which are important features of an effective safety management system,

- Risk analysis process
- Closed loop system (continuous on-going process, periodically review and analyze)

The SMS working team then conducted risk analysis on past major severity avoidable accidents/incidents of the case study company which occurred during the period of January 2003 to December 2004. The SMS working team brainstormed possible potential causes of 4 major failure modes which are common or similar among the 12 cases of major severity avoidable accident/incident. The brainstormed potential causes are classified into categories on fishbone diagrams which are as follows,

- Man
- Machine
- Process
- Substance
- Environment

The next step is to bring 4 major failure modes and the selected 13 major potential causes as identified in fish bone diagrams into FMEA worksheet. Some of the potential causes are filtered out because the SMS working team concluded that the severity or occurrence of the potential effects and causes are of no significant.

The significant high RPN will be taken into consideration for further solution and improvement along with the development of the SMS. The acceptable RPN is determined as 24 and any RPN above this value will be taken into consideration for further solution and improvement along with the proposed safety management system. From FMEA study, there are 9 factors which have high RPN, which required recommended actions to reduce or eliminate the risk associated with the failure mode. The recommended actions are as follows,

- Replacement of equipments that do not have proper safety feature
- Rearrange/expand/relocate parking area
- Revision of policy, procedures and work instructions to include
    - Driver passport system
    - Training system
    - Fatigue of driver management system
    - Accident/incident investigation and analysis

Comparing the pre and post implementation accident/incident rate and financial impacts, may not clearly indicate that the proposed SMS and recommended actions significantly reduce the rate and financial impacts cause by major severity avoidable accident/incident, but with the SMS in place, accident/incident can now be track, identify and analyze, in order to reduce occurrence probability and mitigate the consequences of accidents/incidents.

Although the risk analysis done in this thesis focus on major severity avoidable accident/incident, but from the post implementation accident/incident report, the less severity avoidable accident/incident cases were less than pre implementation period as well. The reason of this phenomenon can not be clearly justified without further investigations, but the author would like to suggest the possibility that with the proposed SMS in place along with the improved SHE policy, management procedure and work instructions may indirectly have effect on reducing the less severity avoidable accident/incident as well.

6.2 Recommendations

Due to the time constraint of the thesis, the SMS and recommended actions proposed in this thesis by the SMS working team only focus on the major severity avoidable accident/incident which only accounted for approximately 12% of all accident/incident which occurred in the year 2004, the author suggest that for the company to achieve continuous improvement in reducing avoidable accident/incident rate and financial impacts, the Safety Steering Committee which will be responsible for maintaining the SMS and its process should investigate further into the less severity avoidable accident/incident. One possibility that can not be ignored is that a minor severity avoidable accident/incident could actually result into a major severity accident/incident. Therefore by reducing the likelihood of the occurrence and applied preventive measure to less severity avoidable accident/incident will indirectly reduce the overall avoidable accident/incident rate and financial impacts caused by avoidable accident/incident.

The ranking scale used for severity, occurrence and detection is 1-5 which do not have a smooth transition between levels when compared to the scale of 1-10. The reason that 1-5 is chosen instead of 1-10 is that at the start of the thesis, most of the members in the SMS working team are not familiar with risk analysis and FMEA, therefore to simplify the method, the author chose the scale of 1-5. Therefore, the author suggest that the Safety Steering Committee which will be responsible for maintaining SMS can improve the risk analysis, in particular the FMEA process by adjusting the scale from 1-5 to 1-10 to allow a smooth transition between levels.

The acceptable RPN can be modified or further improved through changing the combination rating of each factor can be changed to suit the company's future goal or requirements changes. In this thesis, for simplicity reason, the acceptable RPN of value 27 was used by choosing equal rating of each factor as 3 (Severity) x 3 (Occurrence) x 3 (Detection). One disadvantage of using the mentioned rating as calculation for acceptable RPN is that, RPN may not match the goal or requirements of the company and some of the problems may not get solved.

The proposed SMS and recommended actions come with cost. Although the goal of this thesis is to primarily reduce the rate and impact of the major severity avoidable accident/incident, but it did not take into account the additional cost or investment of implementing the proposed SMS and recommended actions. The author

suggests that further analysis can be done by assessing the additional cost and investment of implementing the proposed SMS and recommended actions and compare with the return on reducing the financial impacts of the accident/incident and intangible cost/benefit of losing/gaining existing/new customer. If this analysis can be achieved the case study company would then be able to select or adopt some of the recommended actions which only provide positive return on investment.

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APPENDICES

APPENDIX A: ABC Transportation Co., Ltd.'s SHE Policy

Leadership and Commitment

1. Leadership

ABC Transportation Co.,Ltd. was established in 1995 as a safe handling and delivery of hazardous substances in bulk. Through the company's quality management systems, engineering concepts and operating procedures, ABC Transportation soon became a leader in the safe delivery of hazardous substances in Thailand.

In recognition of the company's commitment to quality and customer satisfaction, ABC Transportation has been awarded with the ISO 9001 (version 2000) certification by BVQI in the year 2001.

2. Management Commitment

All staff and employees are the most important and valuable resources of the company. The Management will try utmost to arrange a safe as well as healthiness environmental at working places for all employees. ABC Transportation will be the leader for the Safe Transporting of Hazardous Substances; our target is no injury for Hospitalization.

3. KPI

All employees is personally responsible for working in a safe manner, following all safety rules, participating in safety training and communications meetings, identifying any safety and health hazards and alerting his supervisor.

ABC Transportation has a goal of zero medical treatment injuries. Plans to achieve this will be developed by Managers in consultation with all employees in his section.

Policy and Strategic Objectives

1. Company's SHE Policy

All employees have to act in accordance with the Company's SHE Policy, Drugs Policy as stated hereunder:

ABC Transportation

Safety, Health and Environmental Policies

All staff and employees are the most important and valuable resources of the company. The Management will try utmost to arrange a safe as well as healthiness environmental at working places for all employees. B. Trans International will be the leader for the Safe Transporting of Hazardous Substances; **our target is no injury for hospitalization.**

Therefore, managing of safety and health at work places is the company policy for everyone to follows hereunder:

1. The company will strictly follows the rules, regulations, announcements, any orders or any SHE standard that being published and enforced by the government authorities.
2. The company will give its full supports to provide training and workshop in regarding SHE in work places for all employees, as well as to arrange necessary activity and continuity in related to safety promotion for individual self awareness in safety vision with sufficient tools and funding as appropriated.
3. The company will give a support on developing the environmental, safety work procedures and will maintain a continuity developing on offices environment, safety and cleanliness to ensure that all employees will have a good surrounding with hygienic at work places that will bring a quality life and happiness to all employees.
4. The company will provide a sound quality standard of personal protective equipment for employees to be used in appropriated to a specific safety requirements. This will includes a strictly monitoring system on the applications of employees to achieve an efficient in safety standard and will use the results of this tracking to measure employee's performance.
5. The company is recognized on employees corporative to follow the enforced rules and regulations on SHE and the success in preventing an incident. This

will includes a measuring system to evaluate the achievement of this policy to ensure that the real efficient and practices are being met.

6. The company is pleased and welcomes any comments and recommendation from employees for its consideration on improving or correcting as appropriated to ensure that the safety standard is being met. However, the company has considered that safety at work places, environmental protection as well as safety work procedures are part of duties and responsibilities of every employee and every management staff level to follows and adhere to it for own safety and others.
7. In the event of an injury on duties, the company will assist the employee to maintain their livings.

Committed and signed by

Managing Director
ABC Transportation Co; Ltd.

ABC Transportation

Anti Drugs Policies

Drugs are at present being dosed amongst school children's, colleges and in many various work places. This will makes significant damages to the country in losing of human resources in the future. The company has realized that this problem may arise in the future; hence we are totally committed to anti drugs in our organization to ensure Drugs Free in our company, therefore the Anti Drugs policies are laid down as a guide lines to adhere as follows:

1. The company will strictly control its employees' behaviors not to use drugs in the company or in any company's vehicles.
2. The company will make its full observation to prevent any sales, supplies on drugs in the company or in company's vehicles.
3. The company will strictly recruit its employees who had no record of drugs involvement.
4. The company will from time to time conduct drugs tests on its employees during their employment period.
5. The company will make it endeavor to promote anti drugs campaign as well as to provide knowledge and training to its employees for awareness of the toxicity and dangers of drugs during their employment period.
6. The company will provide an opportunity to those employees who have been involved with drugs for recovery treatments.
7. The company will make its full cooperative to the competent authorities in searching or testing of drugs from its employees.

Committed and Signed by

Managing Director

ABC Transportation Co; Ltd.

2. Legal requirements and Industry Code

The management of occupational safety and health is an integral part of overall management responsibilities, hence the relevant SHE legislation and system are in places to demonstrate compliance as well as to identify and correct any non compliance. ABC Transportation is taking its full responsibility for any incident and accident that might be caused by its employee activities.

Organization, Responsibility, Resources, Standards and Documentation

1. Organization

SHE is a line management and falls under responsibility at all level of ABC Transportation's employees. The line is taking responsibility by:

- Regularly reviewing SHE performance
- Assessing staff's SHE performance
- Enforcing team accountability for performance
- Discussing approved SHE procedures for understanding and providing fit for purpose equipment for the tasks at hand
- Reporting, investigating and following-up incidents

Personnel shall not be disciplined or face reprisal for refusing to work or for stopping work on the grounds of substantiated health, safety and environment protection concerns. Where work is stopped, corrective action, where appropriate after consultation between the worker, supervisor and SHE adviser must be taken before work is resume.

2. Roles and Responsibilities

ABC Transportation has demonstrated its commitment to SHE through:

(a) Management of SHE:

- Decisions consistent with its SHE policy and objectives.
- Deliberations of SHE matters in every management meetings.
- Report, investigation and follow-up of every SHE incident appropriate to its potential.
- Effort for continuous improvement in all aspects of SHE performance.
- Clearly defined SHE requirements and standards.

(b) Allocation of Resources:

- Making funds and human resources available include planning, execution, supervision, monitoring and feed back reporting.
- Developing and maintaining an organization for effective management of SHE.
- Providing resources to train personnel to do their work competently.

(c) Monitoring and Follow-up:

- Monitoring the implementation of SHE plan and SHE standards, taking steps as appropriate toward compliance.
- To visit all works areas for inspections and audits defined in SHE plan.
- Follow up on implementation of action items arising from incident reports and investigations, inspections and audits.

3. SHE Advisor

In addition to the statutory requirements for the provision of Safety Officer, ABC Transportation has included a SHE Advisor, who is classified as Key Personnel. SHE Advisor is not responsible for line management and supervision, rather his role is to facilitate and advise for SHE plan.

The job functions of SHE Advisor are set out as follows:

- Ability to communicate effectively in written and spoken English.
- Ability to conduct SHE audits/inspection appropriate to the nature of activities.
- Ability to train personnel in incident prevention.
- Ability to conduct incident investigations to identify underlying causes.
- Knowledge of environmental requirements, rules and regulations, monitor compliance and identify ways of reducing environmental impact.
- Be fully conversant with techniques used in the management of hazards and advice suitable measures which can be used for preventing and ultimately recovering from accidents situations.
- Be able to facilitate and develop SHE Plans.

4. Training and Personnel Competency

ABC Transportation is responsible for providing personnel with the skills and SHE training to work in a safe, healthy and environmentally responsible manner.

Competence is defined as “The ability in terms of skill, knowledge, and awareness to perform activities within an occupation or function to specified standards”. All staff is required to have competencies including having received appropriate general training

on the company safety requirements such that they are competent to contribute to the identification and assessment of hazards.

The first priority and absolute requirement will be for staff having accountability for SHE Critical Activities.

SHE-Critical means that incompetent actions by an individual could lead directly to serious injury, fatality and loss containment or major damage to the assets or environment. These activities are normally associated with the Control or Recovery elements of the Hazards and Effects Management Process. Another way of identifying a SHE Critical Activity is that the associated competence is the last barrier that prevents the hazardous event from occurring and that if an incompetent action is undertaken there is no other barrier to intercede.

5. Health risk Assessments and Health Surveillance

Health Risk Assessments are required to be in place for all company staff that associated with all jobs executed by staff.

ABC Transportation is accountable for maintaining Health Surveillance (the measures for monitoring the health) of all its staff who risk to health cannot reasonably excluded. The minimum requirements are to perform a pre-employment physical examination and annual physical examinations with following items;

- Complete blood test
- Urine analysis
- Chest X-ray
- Physical examination by Doctor

Safety Management

1. Drivers Management

- Drivers must undergone driving test prior employment
- Drivers must hold a valid driver's license class IV
- Drivers must undergone basic knowledge of Hazardous substances, Hazard identifications, use of Personnel Protective Equipment.
- Drivers must attend on the Job Training for loading/unloading of specific product that he has to transport.
- Drivers must undergone physical examination once a year

- Drivers must undergone daily alcohol checks prior taking his assignment and once after returning trip to the site.
- Drivers must undergone occasionally drug tests as required by the company

2. Personnel Protective Equipment (PPE)

Drivers must undergone training on how to make a proper use of Personnel Protective Equipment (PPE) in appropriated to the hazardous substances that he is being transported. And use the proper PPE every time that he is involved with hazardous substances product.

3. Emergency Response Procedure

To provide a planned approach enabling support to civil authorities whenever ABC Transportation's vehicles have been involved in an accident/incident. The operations of Emergency Response Plan will be under the control of ABC Transportation. ABC Transportation will be responsible for evaluating the emergency, attending the scene where applicable, contact with civil authorities and arranging specialist advice. Drivers must be well trained for reporting of accident/incident, including basic emergency response actions as appropriated.

4. Vehicles and Equipment Daily Checks

Vehicles and Equipment Daily Checks Sheet is provided for drivers to perform physical checks for readiness of his vehicles and equipment prior taking his assignment for delivering of products and once the vehicles returned to the site. Any malfunctioned or any unusual operations of equipment is detected during inspection will be reported for prompt corrective actions.

5. Permit to Work System

The Permit to Work System is a mandatory competent of the company's safety management, and adherence to it is a prime safety requirement. The work permit stipulates the safety/precautionary measures to be taken before, during, and after the work at the facility. The permit to work system is a key element in ensuring that all necessary steps are taken to ensure the safety of personnel and the safeguarding of company installations.

6. Road Safety Management

ABC Transportation has put in place a system of Road Safety Management for all vehicles within its control. The objective is a formal and auditable system to ensure:

- Only correctly maintained and met right standard vehicles are employed

- Measures usage and percent utilization etc and leads to implementation of improved journey management and the progressive reduction of road exposure.

These incorporate signed daily functional checks; daily checks that maintenance frequencies are not being exceeded.

(a) Maintenance Records

ABC Transportation has a formal system in place for the routine maintenance of all vehicles under its control. The system clearly indicates the maintenance schedule and the work require. Evidence is exists of its execution and verification. All records are made available upon requested.

(b) TACHOGRAPHS / GPS System

TACHOGRAPHS are fitted to all vehicles, except some of the late purchased model that has fitted with the GPS system. TACHOGRAPH records are being analyzed not only to find speed infringements but more important to identify driver patterns and identify opportunities for improving individual skills. Driver counseling are recorded.

Auditing and Review

As part of the registered member of the quality system (ISO 9001:Version2000) that ABC Transportation is being accredited with, therefore Quality Manual, Procedures Manual, Work Instructions are documented and in compliance with the requirements of ISO 9001.

APPENDIX B: ABC Transportation's SHE Management Procedure

1 Objectives

1.1 To enhance all employees at all levels with knowledge and understanding to perform the correct emergency response action once the incident is taking place.
1.2 To take immediate response action to any emergency events that might occur
1.3 To promote understanding and involvement of all employees relating to Safety, Health and Environment (SHE) Management
1.4 To ensure that all operations will be carried out successfully and safely
1.5 To reduce loss of company's resource resulting from unsafe act and improper environmental
1.6 To ensure safety to society and the least affect on company's asset loss and society

2. Scope

The following procedure is for all of the operating sites of the company

3. Definition

Emergency event means any event that had occurred with unexpected that resulted in damages to assets or human.

4. Responsibility

4.1 Safety officer has the duty and responsibility to set up the plan, propose, implementing, auditing and evaluate on safety practices.

4.2. It is the duty and responsibility of Safety department Manager, Safety section Manager or Safety section Assistant Manager to review and approve safety audit plan includes follow-up, facilitate and propose improvement guidelines in connection with the company's quality goal and objectives

5 Procedure

5.1 Process of follow up SHE Management

5.1.1 Safety department set out a follow up plan (FM-ST-01) at least once a year and includes at least following topics

1 Inspection on safety equipments on board the truck (FM-ST-02)
2 Personal Protective Equipments (PPE)
- Inspection of PPE (FM-ST-03)
- Random check on driver usage of PPE (FM-ST-08)
3 Random check on truck condition (FM-ST-12)
4 Inspection of alcohol level and drug presence on truck drivers (FM-ST-06)
5 Inspection of the parking space capacity (FM-ST-07)
6 Inspection of TACHOGRAPH to locate any related problems (FM-ST-09)

5.1.2 Safety department to propose follow up plan to Deputy Managing Director - Operational Department

a. If **disapprove**, safety department will have to review and re-submitting the inspection follow up plan
b. If **approve**, proceed accordingly

5.1.3 Safety department implements the approved inspection follow up plan

5.1.4 Safety department evaluates the resulted of the follow up plan by

a. If the result of the evaluation is failed, then safety department will have to find way to improve and propose the improvements to involve parties for implement and re-evaluating
b. If the result of the evaluation is passed, then safety department will summarize into report and present to the management meeting

5.2 Emergency Response Procedure

5.2.1 Driver involved in an emergency accident/incident must immediately report the accident/incident to the safety officer or any company staff that can be contacted

5.2.2 Receiver of an emergency reporting must interview the reporter for information and details regarding the emergency incident and inform safety officer immediately

5.2.3 Receiver of an emergency reporting must inform safety officer and record the details of the accident/incident into Emergency Reporting Form (FM-ST-04)

5.2.4 Safety officer must report the emergency incident to the following related parties (by his own judgment depending on the severity of the accident/incident)

1. Supervisor
2. Manufacturer
3. related government agencies

5.2.5 Safety Officer must assess the situation base on the information obtained and prepare an emergency response plan

5.2.6 Safety Officer executed an emergency response action according to the plan

5.2.7 Safety Officer concludes the root cause of accident/incident and recommends corrective and preventive measures. In case of MAJOR accident/incident, the safety officer must act according to Corrective and Preventive action Procedure (QP-DC-05)

5.2.8 Safety Officer concludes an emergency report (FM-ST-05) and present the report to management

6. Related Forms

6.1 Annual SHE Inspections Follow Up Plan (FM-ST-01)
6.2 Inspection of Safety Equipments on board the Truck Reporting Form (FM-ST-02)
6.3 Inspection of PPE Reporting Form (FM-ST-03)
6.4 Emergency Incident Reporting Form (FM-ST-04)
6.5 Report of an Emergency Incident/Accident (FM-ST-05)
6.6 Inspection of Alcohol Level and Drug Presence on Truck Driver Report (FM-ST-06)

6.7 Inspection of Parking Space Capacity Report (FM-ST-07)
6.8 Random check on Driver Usage of PPE Report (FM-ST-08)
6.9 Inspection of TACHOGRAPH or SWG to locate any Related Problems Report (FM-ST-09)
6.10 Work Permit (FM-ST-10)
6.11 First Aid Usage Record (FM-ST-11)
6.12 Random Inspection of Truck Condition Report (FM-ST-12)
6.13 Random check of Tire's Tread Depth Report (FM-ST-13)

APPENDIX C: ABC Transportation's Transportation Process Procedure

1 Objectives

1.1 To ensure that all of the delivery orders are carry out completely.

1.2 To provide the correct information and procedure of transportation process for the driver and related person.

2. Scope

The following procedure is for all delivery orders from the customer or the business development department only.

3. Definition

3.1 Customer refers to a person or company that hired the company to transport products.

3.2 Operation supervisors refer to department manager, section manager or assistance section manager of operation department/section.

4. Responsibility

4.1 Driver has the duty and responsibility to follow the step in this procedure strictly.

4.2 Dispatcher has the duty of providing consultation and advice when driver required additional information or when problem arises in the process.

4.3 Dispatcher Admin Officer (DAO) has the duty and responsibility to compile all the delivery related documents, in order to prepare a delivery summary report correctly.

4.4 Safety officer has the duty and responsibility to be the point of contact, prepare and conduct emergency response in case of an emergency.

5 Procedure

5.1 Truck driver can be informed regarding delivery order by two methods as follows

a. receive of delivery order documents from the dispatcher
b. obtained direct order from the supervisor in the case of emergency

5.2 Truck driver must check all the details in the delivery order form, for example loading and unloading locations, type of goods. If there is any doubt which will cause problem to the operation, the truck driver have to ask for additional details from the dispatcher or operation supervisor.

5.3 Truck driver obtains Goods Requisition Form from the dispatcher to use as (only when the goods requisition form is required).

5.4 Truck driver must inspect the readiness of the delivery truck before each trip and record down the inspection result on the truck readiness inspection form.

5.5 Truck driver drive the truck to the loading location to load the goods. Truck driver must abide the rules and regulations of each loading locations very strictly

5.6 After loading of the goods, truck driver must check the type, quantity, orderly of the goods and compare that it is according to the delivery order, if found any faults or discrepancy, the driver must inform the related officer to find preventive measure immediately.

5.7 The driver must contact the related officer to obtain all delivery related documents and check for completeness of the documents before making delivery of the goods.
5.8 The driver must operate carefully in order to deliver the goods safely.
5.9 During the delivery process, if there is any emergency accident/incident that prevent the driver from deliver the goods safely, then the driver must immediately inform the safety officer.
5.10 On the arrival at the unloading destination, the driver must contact the related officer directly before unloading and must carry out his operation according to the rules and regulations of the unloading destination strictly.
5.11 The driver must submit all the delivery related documents to the related officer of the unloading destination, so that he/she can inspect the documents.
    a. If everything is complete and correct, the driver shall confirm with the related officer regarding the unloading point/area before start of unloading process.
    b. If there is any there is any discrepancy found, the driver must immediately contact the dispatcher or operation supervisor.
5.12 The driver must unload the goods according to the instruction given for each type of product.
5.13 After unloading of the goods, the driver must inspect the correctness, completeness and orderliness of the operation. And also the related delivery documents must be signed and given to the related officer. If there is any discrepancy found, the driver must inform the related officer of the unloading destination or the dispatcher or the operation supervisor.
5.14 The driver must drive the truck back to the company site carefully and safely.
5.15 During the drive back to the company site, if there is any emergency accident/incident, the driver must immediately inform the safety officer.
5.16 On the arrival back at the company site, the driver must follow the regulations and procedures of the company, for example fully fill up the fuel tank, parking the vehicle in the designated area. And act as follows:
    5.16.1 Compile all the related delivery documents and submit the documents to the dispatcher or assigned submission point.
    5.16.2 Write a delivery operation trip report using the specified form by filling in the details correctly, completely and according to the fact, then submit the report to the dispatcher or assigned submission point.
    5.16.3 Carry out inspection on readiness of the delivery truck and record down the inspection result on the truck readiness inspection form, then submit the form to the dispatcher or assigned submission point.
    5.16.4 In the case of goods left from delivery process, the driver must record down the detail onto the goods left-over report form and submit the form to the dispatcher or assigned submission point.

6. <u>Related Forms</u>

6.1 Truck Readiness Inspection Form (FM-TR-13)
6.2 Delivery Operation Trip Reporting Form (FM-TR-07)
6.3 Goods Left-over Reporting Form (FM-TR-08)

BIOGRAPHY

Kittipong Putthapornmongkol was born in Bangkok, 1978. He left Thailand in 1990 from Assumption College for Fowlie Primary School, in Singapore and enrolled at St. Patrick's Secondary School for his four years of secondary school education. Upon completion of 'O' Level at St. Patrick's Secondary School, he then spent the next one and a half years at David Game Tutorial College, London doing his 'A' Level. Three years after the completion of his 'A' Level, he graduated from University College London with a Bachelor of Engineering in Engineering with Business Finance in 2001. Currently, he is pursuing a Master degree in Engineering Business Management at Regional Centre for Manufacturing Systems Engineering, Chulalongkorn University, Thailand and University of Warwick, England.