PREPARATION TO ACHIEVE ISO / DIS 45001:2017 CLAUSE 6 AND IMPLEMENTATION OF FMEA TO REDUCE POTENTIAL OF ACCIDENTS RATE ON A CEMENT WAGON MANUFACTURING PROCESS

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ABSTRACT

Reducing accident rate is a major focus of every company. Thus, several technique have been used in order to solve the problems. One of the technique that can be used is ISO 45001:2017. This paper aims to reducing the potential of accident at PT.XYZ by implementing ISO 45001:2017 clause 6 to the current management system and using FMEA to identify the hazard. Before conducting the analysis, there is a needs to know the product that its processes has the most accident in the company. After that, the data that concern to the PT. XYZ management system and the manufacturing process needs to be collected and analyzed. After both analysis have been conducted, the next will be to find a linkage between the FMEA's hazard problems with the ISO 45001:2017 clause 6's solution. The findings reveals that PT. XYZ has almost fulfil all of the requirement of ISO 45001:2017 clause 6 and the hazard control performance is 81.81% which is not a good number for PT. XYZ. The reason is PT. XYZ aims to have zero accident in a year. To accomplish this goal, PT. XYZ needs to build a good management systems.

Keywords: *Accident rate, ISO 45001:2017, FMEA, emergency, management system, hazard control performance*

CHAPTER I
INTRODUCTION

1.1 Problem Background

Nowadays, the manufacturing companies need to maintain their production rate while trying to improve it. As in Indonesia, the ASEAN Economic Community (AEC) regulation that recently take place has begun to take its effect. AEC itself is an agreement among the ASEAN countries that has agreed to make a free trade regulation among its participant. So, there is little restriction or even there is no restriction in export or import between the ASEAN countries. It's not only can become as an opportunities but also a challenge to the local industries.

Indonesia's government has been established many public policies that bind the company to take care of its employees. Although the policies still being in implementation process, companies should really focused on the employees safety. Companies can design a work system where the risk of injury would be smaller. By doing so, companies have helped their employees to work at its full potential or high performance knowing there is no harm will be awaited for them.

PT. XYZ is one leading heavy equipment manufacturing company that located at west java, Indonesia. PT. XYZ is company that engaged in the mining, forestry, construction, industrial equipment, and shipbuilding field. PT. XYZ is an order-to-make company. Which means that the company will make a product based on the order. Naturally, company that has many variation could be both good and bad. It would be good because all of the worker will have broad skills in manufacturing. It also become bad because with many variety of methods there is a high chance of accident.

Currently, the company has been implemented OHSAS 18001:2007 to achieve the goal which is zero accident per year. But, the company has failed to achieve this objective due to the occurrences of several accident in the manufacturing process.

Because of that, the company aims to update its management system by using ISO 45001:2017 in order to achieve the goal in the next year. This countermeasure was taken because the management system needs to be always updated to prevent the unwanted accident in the workplace.

In this year, PT. XYZ got 5 accidents occurred in the factory. Although the accidents did not major loss, PT. XYZ suffered big loss due to damaged assets and labor's medical cost. Because of that reason, the company intended to get the ISO certificate in order to keep the loss to minimal and widen its market. PT. XYZ has its own management system but not ISO certified. To ensure that the company's current management system is fulfilled the ISO 45001:2017, the company will need to conduct gap analysis between the current system and ISO 45001:2017. Then, the internal auditing is necessary before conducting external auditing.

In many cases, accident usually happened because of lack of awareness the operators. Lack of awareness happened because the operators do not have any knowledge about the risk that involved in their working area. Because of this, the chance of risk is pretty high. Therefore, the company needs to take an action to reduce the chance of risk. The action to reduce chance of risk called risk management. Risk management is very useful to company. It is used to reduce the risk of the job and also to reduce the production cost of a company.

1.2 Problem Statement

The background of the problem leads into the statement below.

- What is the current OHS management in the PT. XYZ that lacking the requirement to achieve ISO 45001 clause 6 criteria?
- What are the current highest accident risk priority number (RPN) score in the manufacturing process and hazard control performance of PT. XYZ according to FMEA?
- How to reduce accident rate in PT. XYZ?

1.3 Objectives

The main objective of this project are:

- To evaluate the current management system based ISO 45001:2017 clause 6 in PT. XYZ
- To conduct accident risk assessment in PT. XYZ
- To know the method of reducing accident rate

1.4 Scope

Due to limited time and resources in doing this research, there will be some scopes in the observation which are:

- The data of this report were taken from period June – December 2016
- Only one product that is going to be observed
- Only certain clause that has linkages to risk reduction that will be used as reference

1.5 Assumption

There are some assumptions made to support the research:

- The workers are obedient to the existing management system

1.6 Research Outline

Chapter I Introduction

This chapter is contains the background of research project which elaborate about the research problem, objective, scope, and assumption of the study. It contains a brief explanation of problem in which going to be solved in this research.

Chapter II Literature Study

This chapter delivers the previous study about the management system, ISO 45001, FMEA, and root cause analysis which support this research study.

Chapter III **Research Methodology**

The flow of this research project and the instrument for the research is explained in this chapter. It also explain in detail about the phase of the research from the beginning until drawing the conclusion.

Chapter IV **Data Collection and Data Analysis**

The data observation is processed and analyzed in this chapter. The data obtained by observation and from the data that has been collected by the staff.

Chapter V **Conclusion and Recommendation**

This chapter will give the conclusion result of this research project, and also recommendation for future research.

CHAPTER II
LITERATURE STUDY

2.1 Risk

Every activities has a risk. Risk is a word that used to describe cases of known probability. Risk defined as the combination of an asset with a threat capable of damaging that asset (Louis et al., 2008). Risks are often discussed in a negative context and the word risk is often described as an undesirable state. The society for risk analysis (SRA), 2012 describes a risk as "the potential for realization of unwanted, adverse consequences to human life, health, property, or the environment..." However, the risk does not always result in a negative result since some risks are taken purely by the expectation of a positive outcome. For example, the acquisition of a company means taking a major risk, but the risk would most likely not been taken if there was no chance of a positive effect (Hopkin, 2012).

Hopkin (2012), presents three types of risks that will result in different outcomes; hazard risks, control risks and opportunity risks. The first category, the hazard risks, the outcome is always negative towards the company. The second category is control risks, the outcome of the control risk contains uncertainty. For the third type of risk, the opportunity risks, will most likely to have positive outcome to the company.

Table 2.1 Example on three categories of computer risks (*Source: Hopkin, 2012)*

Type of risk	**Risk event**	**Outcome**
HAZARD	Virus infection	Negative
CONTROL	Upgrading of old software	Uncertain
OPPORTUNITY	Installation of new software	Intentionally positive, but can also negative

2.2 Risk Management

Risk management is a process to increase the probability of success and reduce the failure rate of a work. In order for the process to work properly. Risk management maintains that the residual risk should be analyzed both with respect to the

probabilistic and the nature of hazard, and hence give information for further risk mitigation (Heinz, 2010). This implies that very unlikely events might be tolerated. Risk management is about making decisions that contribute to the achievement of an organization's objectives by applying it both at the individual activity level and in functional areas (Heinz, 2010). It assists with decisions such as the reconciliation of science-based evidence and other factors; costs with benefits and expectations in investing limited public resources; and the governance and control structures needed to support due diligence, responsible risk-taking, innovation and accountability (Heinz, 2010).

2.2.1 Risk Management Steps and Tools

The risk management steps are:

1. Establishing goals and context (i.e. the risk environment)
2. Identifying risks
3. Analyzing the identified risks
4. Assessing or evaluating the risks
5. Treating or managing the risks
6. Monitoring and reviewing the risks and the risk environment regularly
7. Continuously communicating, consulting with stakeholders and reporting.

The establishment of the context and culture is undertaken through a number of environmental analyses that include, e.g., a review of the regulatory requirements, codes and standards, industry guidelines as well as the relevant corporate documents and the previous year’s risk management and business plans.

Part of this step is also to develop risk criteria. The criteria should reflect the context defined, often depending on an internal policies, goals and objectives of the organization and the interests of stakeholders. Criteria may be affected by the perceptions of stakeholders and by legal or regulatory requirements.

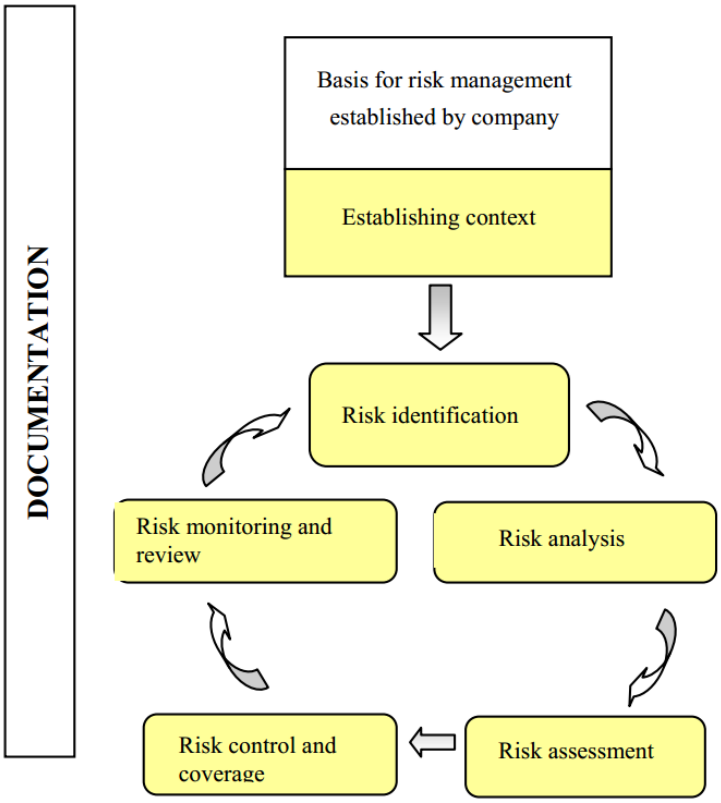


Figure 2.1 Risk Management Process (*Source: Heinz, 2010)*

It is important that appropriate criteria be determined at the outset. Although the broad criteria for making decisions are initially developed as part of establishing the risk management context, they may be further developed and refined subsequently as particular risks are identified and risk analysis techniques are chosen. The risk criteria must correspond to the type of risks and the way in which risk levels are expressed.

One of the tool that regularly used to decrease the number of accident and to identify the potential risk is Failure Modes and Effects Analysis. It is a tool that used to prevent the accident.

2.2.2 Failure Modes and Effects Analysis (FMEA)

The Failure Modes and Effects Analysis (FMEA), also known as Failure Modes, Effects, and Criticality Analysis (FMECA), is a systematic method by which potential failures of a product or process design are identified, analyzes and documented. Once identified, the effects of these failures on performance and safety are recognized, and appropriate actions are taken to eliminate or minimize the

effects of these failures. An FMEA is a crucial reliability tool that helps avoid costs incurred from product failure and liability.

Failure Mode Effects and Criticality Analysis (FMECA) is similar to FMEA, with the added step of a more formal Criticality Analysis. This added step commonly requires objective data to support the criticality calculation. It is recommended for practitioners who are required to perform a FMECA analysis to understand the basics of FMEA first, and then to learn the FMECA procedure. Some other types of FMEAs include Concept FMEA, a short version of FMEA to aid in selecting optimum concept alternatives or to determine changes to system design specifications; Maintenance FMEA, in support of Reliability Centered Maintenance projects; Hazard Analysis, which focuses on identifying and addressing potential hazards associated with the use of a product; and Software FMEA, which identifies system weaknesses, and evaluates the effectiveness of the software architecture and software specifications.

The FMEA process is an on-going, bottom-up approach typically utilized in three areas of product realization and use, namely design, manufacturing and service. A design FMEA examines potential product failures and the effects of these failures to the end user, while a manufacturing or process FMEA examines the variables that can affect the quality of a process. The aim of a service FMEA is to prevent the misuse or misrepresentation of the tools and materials used in servicing a product.

2.2.2.1 Types of FMEA

The most common types of FMEAs are System FMEA, Design FMEA and Process FMEA.

System FMEA is the highest-level analysis of an entire system, made up of various subsystems. The focus is on system-related deficiencies, including system safety, system integration, interfaces or interactions between subsystems or with other systems, interactions with the surrounding environment, human interaction, service, and other issues that could cause the overall system not to work as intended. In

System FMEAs, the focus is on functions and relationships that are *unique* to the system as a whole (i.e., do not exist at lower levels). Included are failure modes associated with interfaces and interactions, in addition to considering single point failures (where a single component failure can result in complete failure of the entire system). Some practitioners separate out human interaction and service into their own respective FMEA.

Design FMEA focuses on product design, typically at the subsystem or component level. The focus is on design related deficiencies, with emphasis on improving the design and ensuring product operation is safe and reliable during the useful life of the equipment. The scope of the Design FMEA includes the subsystem or component itself, as well as the interfaces between adjacent components. Design FMEA usually assumes the product will be manufactured according to specifications.

Process FMEA focuses on the manufacturing or assembly process, emphasizing how the manufacturing process can be improved to ensure that a product is built to design requirements in a safe manner, with minimal downtime, scrap and rework. The scope of a Process FMEA can include manufacturing and assembly operations, shipping, incoming parts, transporting of materials, storage, conveyors, tool maintenance, and labelling. Process FMEAs most often assume the design is sound.

As mentioned in chapter 1, company will do anything to reduce the accident rate to maximize the profit, one of the possible ways is to reduce the medical expense of its employees. By conducting failure modes and effects analysis, it is expected to reduce the numbers of accident in the workplace.
Failure Mode and Effects Analysis is a method designed to:

- ✓ Identify and fully understand potential failure modes and their causes, and the effects of failure on the system or end users, for a given product or process.
- ✓ Assess the risk associated with the identified failure modes, effects and causes, and prioritize issues for corrective action.

- ✓ Identify and carry out corrective actions to address the most serious concerns.

FMEA is an engineering analysis done by a cross functional team of subject matter experts that thoroughly analyzes product designs or manufacturing processes, early in the product development process. Its objective is finding and correcting weaknesses before the product gets into the hands of the customer (Carlson, 2012).

FMEA should be the guide to the development of a complete set of actions that will reduce risk associated with the system, subsystem, and component or manufacturing/assembly process to an acceptable level (Carlson, 2012). Performing an FMEA just to fill a checkbox in the Product Development Process and then filing it away, never to be seen again, is a waste of time and adds no value. If not for use as guidance through the development process, why waste the time and resources to do it in the first place? If effectively used throughout the product life cycle, it will result in significant improvements to reliability, safety, quality, delivery, and cost (Carlson, 2012).

The primary objective of an FMEA is to improve the design. For System FMEAs, the objective is to improve the design of the system. For Design FMEAs, the objective is to improve the design of the subsystem or component. For Process FMEAs, the objective is to improve the design of the manufacturing process (Carlson, 2012).

2.2.2.2 Conducting FMEA

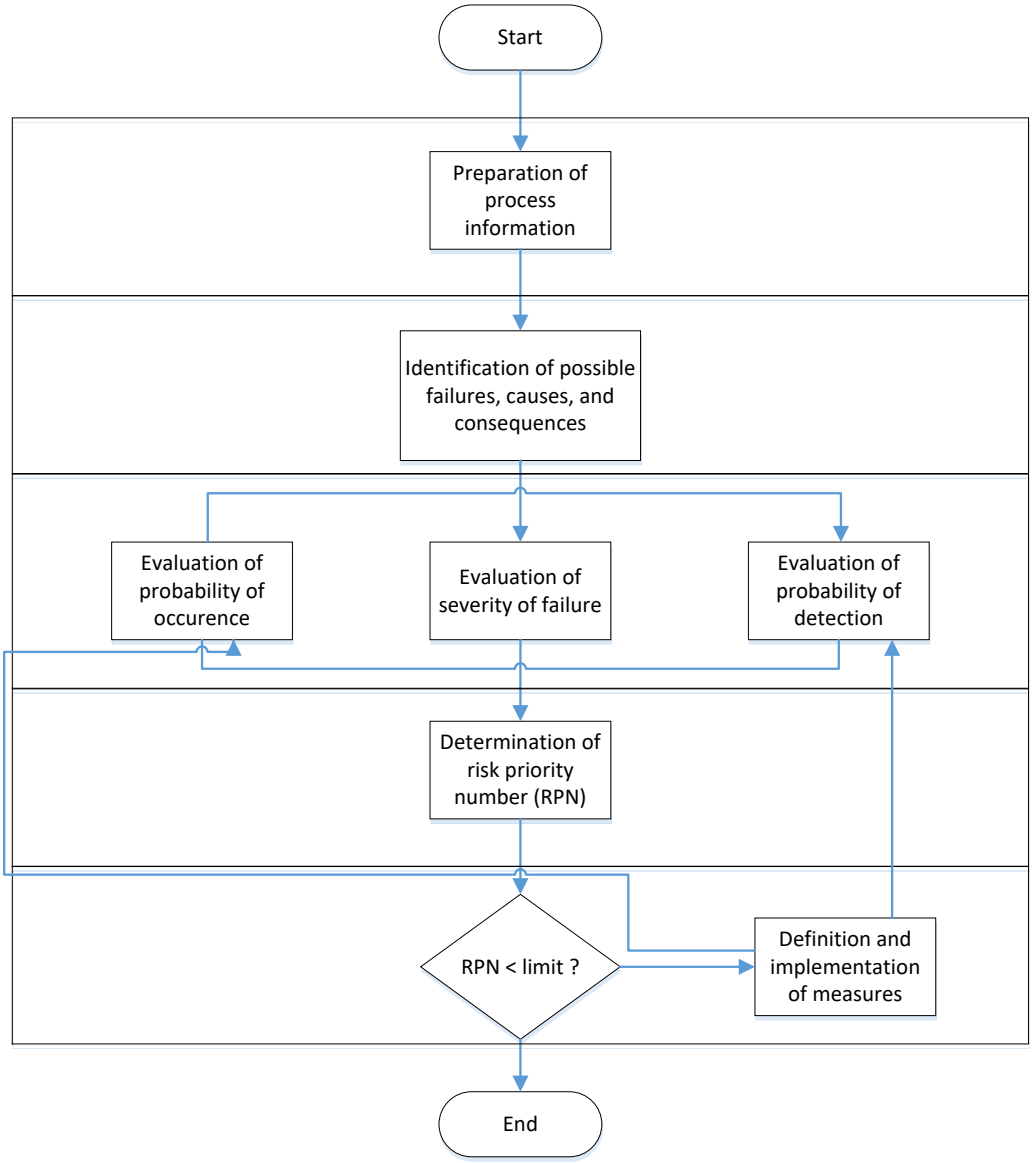


Figure 2.2 FMEA Flow Chart (*Source: Ayaniyat, et al. 2015)*

Steps to conduct FMEA:

1. Identify components and associated functions
2. Identify failure modes
3. Identify effects of the failure modes
4. Determine severity of the failure mode
5. Identify causes(s) of the failure mode
6. Determine probability of occurrence
7. Identify controls
8. Calculate risk priority number

9. Conduct criticality analysis
10. Determine actions to reduce risk of failure mode

2.2.2.3 FMEA Scale for Calculating Severity, Occurrence, and Severity

Severity Scale for FMEA (scale 1 [least severe] to 10 [most severe] for each effect)

Table 2.2 Severity Scale for FMEA

Minor (Rank 1)	Unreasonable to expect that the minor nature of this failure will have any noticeable effect on item or system performance or subsequent process or assembly operation. Customer will most likely not be able to detect the failure.
Low (Rank 2 - 3)	Due to the nature of this failure, the customer experiences only slight annoyance. Customer will probably notice slight deterioration of the item or system performance or a slight inconvenience with a subsequent process or assembly operation, i.e. minor rework.
Moderate (Rank 4 – 6)	Failure causes some customer dissatisfaction which may include discomfort or annoyance. Customer will notice item or system performance deterioration. This may result in unscheduled rework/repair and/or damage to equipment.
High (Rank 7 – 8)	High degree of customer dissatisfaction due to the nature of the failure, such as inoperable item or system. Failure does not involve safety or government regulation. May result in serious disruption to subsequent processing or assembly operations and/or require major rework.
Very High (Rank 9 – 10)	Failure affects safety or involves noncompliance to government regulations. May endanger machine or assembly operator (9 with warning, 10 without warning)

(Source: Hansen, 2016)

Occurrence Scale for FMEA (scale 1 [least frequent] to 10 [most frequent] for each root cause)

Table 2.3 Occurrence Scale for FMEA

Remote (Rank 1)	Failure unlikely. No failures ever associated with this process or almost identical processes (1=1:1.5M)
Very Low (Rank 2)	Only isolated failures associated with this process or almost identical processes (2=1:150K)

Source: Hansen, 2016

Table 2.3 Occurrence Scale for FMEA *(Cont'd)*

Low (Rank 3 – 5)	Isolated failures associated with similar processes (3= 1:30K; 4=1:4500; 5=1:800)
Moderate (Rank 6 – 7)	This process has occasional failures, but not in major proportions (6=1:150: 7=1:50)
High (Rank 8 – 9)	This process or similar processes have often failed (8=1:9; 9=1:6)
Very High (Rank 10)	Failure is almost inevitable (10=>1:3)

Source: Hansen, 2016

Detection Scale for FMEA (scale 1 [always detected] to 10 [never detected] for each occurrence)

Table 2.4 Detection Scale for FMEA

Very High (Rank 1 – 2)	Current controls almost certain to detect the failure mode. Reliable detection controls are known with similar Processes. Process automatically prevents further processing.
High (Rank 3 – 4)	Controls have a good chance of detecting failure mode, process automatically detects failure mode.
Moderate (Rank 5 – 6)	Controls may detect the existence of a failure mode.
Low (Rank 7 – 8)	Controls have a poor chance of detecting the existence of failure mode
Very Low (Rank 9)	Controls probably will not detect the existence of failure mode
Absolutely No Detection (Rank 10)	Controls will not or cannot detect the existence of a failure. No known controls available to detect failure mode.

(*Source: Hansen, 2016)*

2.3 ISO 45001

ISO 45001 is a new international standard for occupational health and safety (OHS), providing framework for managing the prevention of death, work-related injury and ill health, with the intended outcome of improving and providing a safe and healthy workplace for workers and persons under an organization's control.

ISO 45001 is a management systems that has taken into account another international standard such as OHSAS 18001. The standard is intended to help an organization regardless of size or industry, in designing systems to proactively prevent injury and ill health. All of its requirements are designed to be integrated into an organization's management processes.

2.3.1 History

Already long time ago, people discovered that any work and working tools bring a variety of dangers of accidents and therefore they have been looking for ways how to prevent the injuries. Step by step the security measures were creating with the complexity and the division of labor. The development of the manufactures and the industrial revolution brought new problems relating to safety at work and technical equipment. People worked several hours a day, including children. When the employee had the injury, it was only his/her matter. They were dismissed from work without any right. In the middle of the 19thcentury the industrial states began to protect the employees through the laws and determined to ensure the safety at work for employers. Great War destroyed the first attempts at international agreements to prevent the injuries

In 1919 International Labor Organization (ILO) was formed in order in order to create the international principles for the protection of labor, implement them into national laws of the Member States and to manage their application. So far, about190 conventions were adopted for the protection of labor and many of them also relate to safety at work. In 1989 Council Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work was adopted. This directive defined the principles of the prevention, framework responsibilities of employers and employees. The implementing directives followed this directive and determined the Occupation Health and Safety (OSH) requirements of workers, working conditions and working environment with a focus on work equipment, protective equipment, manipulation with loads, work with screens, asbestos, chemical substances and so on.

The area of OSH was complicated and therefore the effective health and safety management system was issued. In addition to health and safety of employees and other persons concerned, this management system ensured the safety of manufacturing facilities as well. The publication of OHSAS 18001:1999 was very important.

2.3.2 Content

There are 11 key changes that the new ISO 45001 brought. They are structure of international standard, organizational context, understanding needs & expectations of interested parties, leadership, worker participation, hazard identification, risk planning, need to prevent ill-health & injuries, documented information, outsourcing & contractors, and OH&S performance evaluation. But, due to this research only focused on the specific clause, only clause 6 key change will be explained thoroughly.

Key change 6: Hazard Identification/Assessment of Risk (Clause 6)

Hazard identification should proactively identify any sources or situation from organizations activities, with potential for work-related injury & ill health. Source/situation could include, but not limited to:

- Sources: hazardous substances, radiation, temperature, pressure, dust, noise & vibration
- Situation: working at height, working in confined space, working alone, worker fatigue, aggressive behavior or harassment, workload and task control
- Hazard can be categorized in many ways, including: physical, chemical, biological psychosocial, physiological; or mechanical and electrical; or based on movement and energy.

Organization shall establish, implement and maintain a process for on-going proactive identification of hazards arising, taking into account, but not limited to:

1. Routine and non-routine activities and situations, including:
    a. Infrastructure, equipment, material substances & physical conditions in the workplace
    b. Hazards that arise as a result of product design
    c. Human factors
    d. How the work is actually done
2. Emergency situations
3. People, including consideration of:

a. Those who access workplace, including workers, contractors, visitors and other persons
b. Those in vicinity of workplace that can be affected by organizations activities
c. Workers at location not under direct control of organization

4. Actual or proposed changes in the organization, operations, processes activities & OH&S management systems
5. Changes in knowledge of or information about hazards
6. Past incidents, internal/external to the organization including the emergencies and their causes
7. How work is organized, and social factors, including workload, work hours, leadership and culture of organization

Key change 7: Planning (Clause 6)

When planning for OH&S management system, organization shall

- Consider issues referred to in "organization context" (4.1)
- Requirement referred to in "interested parties" (4.2)
- Scope of its OH&S management (4.3)
- Determine risks and opportunities that need to be addressed

When planning how to achieve OH&S objectives, the organization shall determine:

1. What will be done
2. What resources will be required
3. Who will be responsible
4. When it will be completed
5. How it will be measured through indicators (if practicable) & monitored
6. How results will be evaluated
7. How the actions to achieve OH&S objectives will be integrated into organizations business process

Key change 8: Need to prevent ill-health/injuries (Clause 6)

ILO ILS recommend that where workers identify circumstances of danger or hazardous environmental which can cause injury and ill health, they should be able to remove themselves & inform the organization of the circumstances without risk of penalization.

Five basic commitments for OH&S policy in ISO 45001

- Provide safe & healthy working condition for the prevention of work-related injury & ill;
- Satisfy applicable legal requirements & other requirements
- Control OH&S risks using the hierarchy of controls (see 8.12)
- Continual improvement of OH&S management system to enhance OH&S performance
- Participation

Table 2.5 Comparing ISO 45001 to OHSAS 18001

ISO 45001 (DIS 1)	OHSAS 18001:2007
6 Planning (title only)	4.3 Planning (title only)
6.1 Actions to address risks and opportunities (title only)	
6.1.1 General	
6.1.2 Hazard identification and assessment of OH&S risks (title only) 6.1.2.1 Hazard identification 6.1.2.2 Assessment of OH&S risks and other risks to the OH&S management system	4.3.1 Hazard identification, risk assessment and determining controls
6.1.2.3 Identification of OH&S opportunities and other opportunities	
6.1.3 Determination of applicable legal requirements and other requirements	4.3.2 Legal and other requirements
6.1.4 Planning to take action	
6.2 OH&S objectives and planning to achieve them (title only) 6.2.1 OH&S objectives 6.2.2 Planning to achieve OH&s objectives	4.3.3 Objectives and programme(s)

Source: NSF-ISR, 2016

Table 2.6 Explanation about the ISO 45001 changes

6. Planning	
6.1 Actions to address risks and opportunities	This clause has been revised and combines some of the clauses of OHSAS 18001 resulting in a broader concept that includes opportunities and measures of effectiveness.
6.1.1 General	
6.1.2 Hazard identification and assessment of OH&S risks	This clause and its sub clauses offer all the requirements for identifying hazards and assessing OH&S risks, and in general, this process is the same as required in the OHSAS 18001 standard. In order for an OHSMS to work effectively a company has to identify all the risks presented by its processes and then assess the risk in the hazards.
6.1.2.1 Hazard Identification	ISO 45001 requires a company to design the identification process in a proactive manner based on the possible risks that may arise from the operations of the company. This identification of risks and hazards must take into account the following: • Routine and non-routine activities • Emergency situations • People who are involved • Other issues that include the design of the workplace • Changes in the company • Changes in information about the dangers • The incidents of the past

Source: PECB, 2016

Table 2.6 Explanation about the ISO 45001 changes (Cont'd)

6.1.1 General	
6.1.2.2 Assessment of OH&S risks and other risks to the OH& Management system	The risk assessment still requires that the risks of hazards are identified and lead to the prevention of occupational hazards and its operations. These criteria must be defined by the company, as it will be different from one company to another.
6.2 OH&S objectives and planning to achieve them	1. Set goals and objectives as part of the planning process. 2. Word the goals and objectives clearly. 3. Goals and objectives must be realistic. 4. Accomplishing goals and objectives must be under the responsible person's influence or control. 5. Objectives must be assigned to someone. 6. Completion dates must be established for each objective and goal.

Source: PECB, 2016

2.3.3 Benefits of ISO 45001

ISO 45001 implement multiple of ISO management system in which making integration of other standards easier such as ISO 9001 for quality management and ISO 14001 environmental management systems. It uses a simple PDCA model which provide a framework for organizations to plan what they need to put in place in order to minimize the risk of harm. The measures should address concerns that can lead to long-term health issue and absence from work as well as those that give rise to accidents.

2.3.4 OHS KPI tools

Occupational Health and Safety key performance index tools main goal is to facilitate the improvement of effectiveness of OHS management system by incorporating resilience features into those systems (Podgorski, 2015). KPI tools is used to know the change between old and new applied systems. There are 3 approaches to measure the OHS management system operational performance which are:

1. Result-based approach using lagging indicators)
2. Compliance-based approach (using leading indicators)
3. Process-based approach (using leading indicators)

Because of in this research focused on the clause 6 of ISO/DIS 45001:2017, the KPI only explained about the planning section.

Table 2.7 KPI explanation

OSH MS area		No	Acronym		KPI definition	OSH MS component	Meas. Frequency
Planning	Risk management	5	HC	HazCntrl	Percentage of hazards with control measures applied (against the total number of new hazards identified in a given reporting period)	Hazard identification	Quarterly
		6	HR	HazRevd (alternative)	Percentage of hazards investigations revied according to schedule in a given reporting period (against the total number of identified hazards)		Quarterly
		7	RA	RiskAssd	Percentage of OSH risk assessments completed or reviewed in a given reporting period (against the total number of OSH risk assessments planned)	Assessment of OSH risks	Quarterly
		8	RC	RiskCntrl	Percentage of OSH risk control measures successfully completed in a given reporting period (against the total number of risk control measures planned for implementation)	Planning to take action	Monthly or weekly
	OSH plans	9	OA	ObjAchvd	Percentage of OSH objectives achieved according to the plans in a given reporting period (against the total number of OSH objective)	Planning to achieve OSH objective	Yearly

Source: Podgorski, 2015

Source: Podgorski, 2015

5. HC HazCntrl
[1] Acronym:

[2] KPI name:
Percentage of hazards with control measures applied (against the total number of new hazards identified in a given reporting period)

[3] OSH MS component: **6.1.2. Hazard Identification**

[4] **Necessary data to calculate the KPI:**

X_i - No. of newly identified hazards[1] in *i*-th unit, in respect to which appropriate control measures have been implemented according to schedule[2] within a given reporting period;

Y_i - Total no. of newly identified hazards in *i*-th unit, in respect to which appropriate control measures should have been implemented within a given reporting period;

N - No. of units conducting hazard identification and collecting data on newly identified hazards.

[5] **Calculation formula:**

$$HC_i = X_i / Y_i \cdot 100\%$$

$$HC = \left(\sum_{i=1}^{N} HC_i\right) / N$$

[1] Hazards identified at new workstations, in new processes/machines, or hazards identified as new ones at existing workstations/processes. The number of newly identified hazard may refer to hazards identified prior or within a reporting period.

[2] The length of the period required for planning and the implementation of control measures after the identification of a hazard can be specified (e.g. no. of days) or unlimited.

[6] **Source of data:** Internal reports or records resulting from risk assessment/management processes, which include the identification of hazards in individual units of the enterprise (maintained by heads of the units and/or by the safety manager/OSH department).

[7] **Measurement frequency:**
Quarterly

[8] **Graphical representation:**
HC current value: semicircular speedometer (with colour policy)
HC_i current values: vertical bars (one for each unit[3], but ≤ 10)
HC historical values: vertical bars for X past reporting periods[3]
[3] No. of bars for units & periods should be set up by the user (no. ≤ 10).

[9] **Colour policy:**
Red: HC < 70%
Yellow: 70% ≤ HC ≤ 90%
Green: HC > 90%

[10] **The method of the KPI implementation in the enterprise:**

- Reviewing procedures, reports and other OSH MS documents related to hazard identification, risk assessment and implementation of control measures aimed at elimination/reduction of risks;
- Identification of units/positions which are responsible for conducting and documenting results of hazard identification and risk management procedures;
- Modification of respective procedures to ensure ongoing identification and regular reporting a number and types of newly identified hazards to a responsible OSH unit.

Figure 2.3 KPI calculation example

2.3.5 RPN categorization

(*Source: DAIMLER, 2013)*

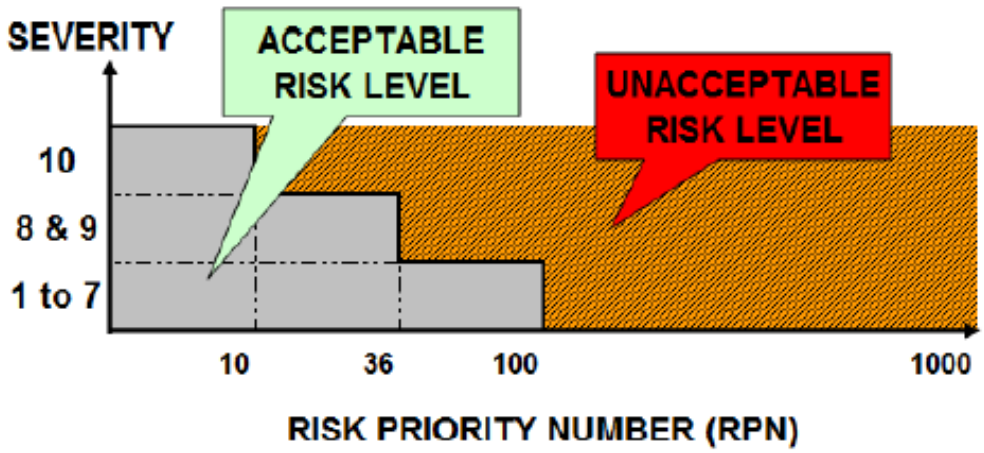


Figure 2.4 RPN categorization

Notes:

If RPN score is below 125 the current risk control remain and suffice, if RPN score is score is more than 125 it needs to have an improvement plan.

Risk level Low: RPN ≤ 125

Risk level Medium: RPN > 125, RPN ≤ 360

Risk level High: RPN > 360

2.4 The Manufacturing Process of Cement Wagon

Among many new orders that PT. XYZ received from the customers, cement wagon was chosen to represent its FMEA for the research. Cement wagon was chosen because it has the highest number of order. Cement wagon also require many treatment that require supervision from the higher-ups. So, to fully understand the risk level of working on cement wagon, the process of making cement wagon and the risk probability will be fully explained in the next chapter.

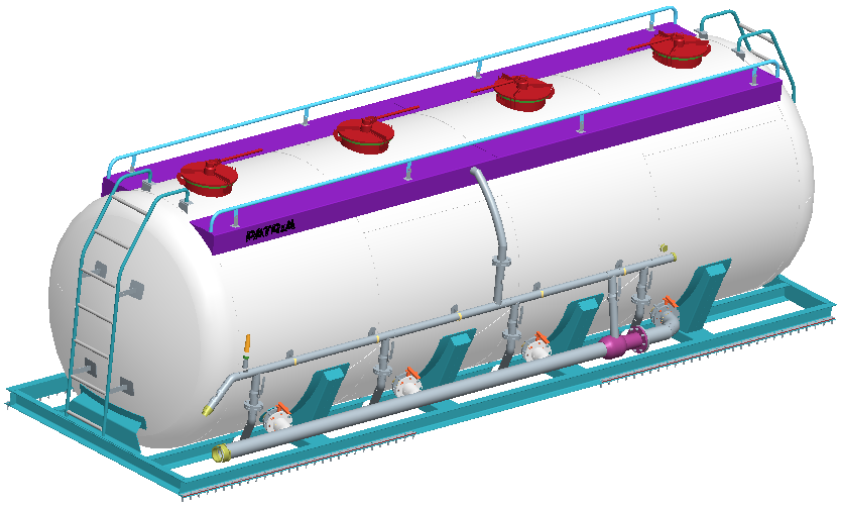


Figure 2.5 3D Model of Cement Wagon

1. Preparation skin & disc end

   The first process of making cement wagon is to prepare any necessary material that will be used for the next step of manufacturing.

Figure 2.6 The Material for Cement Wagon

2. Join skin (Welding)

   The next process is to weld the skin that has been prepared before.

Figure 2.7 Welding Material to Make a Tank

3. Setting pipe (sub assembly)

   Before going to the next step, setting the pipe is necessary in order to keep the manufacturing process on schedule.

Figure 2.8 Assembly the pipe parts

4. Full weld skin

   The fourth step is to full weld the skin. It is done by welding the joined skin (step 2) then close one of its end with disc end.

Figure 2.9 Welding The Outer Parts

5. Full weld cone with bottom flanging

   The next step is to prepare the part for next process. This part will be used as operators footing place in the tank.

Figure 2.10 Welding The Cone With Bottom Flanging

6. Make pipe hole on body skin

   The next step is to make a hole on the work piece. It is done by using LPG cutting tool.

Figure 2.11 Make A Hole on Body Skin

7. Setting cone assembly

   The next step is to assembly the inner parts of cement wagon. The inner parts consist of bottom flanging, pipe, foothold, etc.

Figure 2.12 Setting Cone Assembly

8. Setting frame

   The next step is to make a preparation of cement wagon base. Then, after the frame has been set, cement wagon will be placed over the frame.

Figure 2.13 Setting Frame

9. Full weld assembled cone

   The next step is to weld the inner part that has been assembled before. This process serves to prevent the leaking from the inside

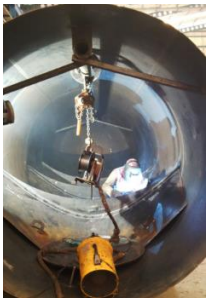


Figure 2.14 Full Weld Assembled Cone

10. Assembly stairs (2 pcs)

    The next step is to assembly stairs for its accessories. This process done by assembling the parts to the main workpiece by using bolts.

Figure 2.15 Assembly Stairs

11. Full weld and assembly man hole (4 pcs)

    The next process is to weld man hole to the main workpiece. This process done by welding the man hole.

Figure 2.16 Full Weld Man Hole

12. Close disc end

    After the working process for the inner part is done, the next step is to close the other end of the cement wagon

Figure 2.17 Welding The Disc End

13. Welding frame & pipe to the main workpiece

    The next step is to welding the frame and pipe to the main workpiece. The pipe will be welded on the hole that has been made before.

Figure 2.18 Joint to Frame & Pipe Assembly

14. Finishing & accessories

    This process to assembly the accessories to the main work piece. This process add the foothold and fences on the top of the main workpiece.

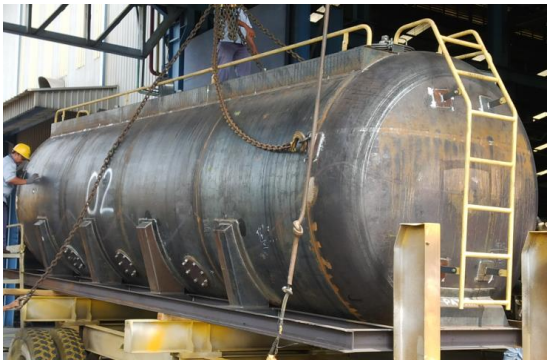


Figure 2.19 Finishing Process

15. Air Pressure & loading unloading test

Figure 2.20 Air Pressure Test & Final Check

16. Painting the product

Figure 2.21 Painted product

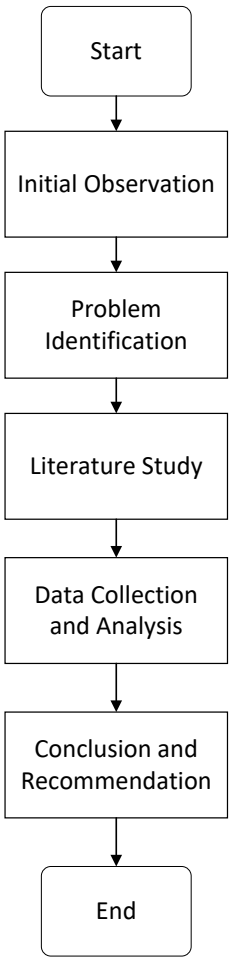
17. Repair or rework (optional)

There are no photos of cement wagon being painted because of the company policy that prevent people to enter the painting room except the operators and the leaders due to the hazards that may occurred in the room. The final process of making cement wagon is to test the product by using soap and water. After that, the final check will be loading and unloading test. After that, the product will be painted by painting department. After painting process, the product will go through the painting inspection. After the inspection is done, cement wagon ready to be ship to the customers.

CHAPTER III
RESEARCH METHODOLOGY

A qualitative method was applied as the research and analysis method. It used because most of the data is in non-numerical. This method is very useful for the research that involved with pre-existing data.

3.1 Research Framework



Initial Observation :
- Initial observation on management system at PT. XYZ
- Initial observation on manufacturing process at PT. XYZ

Problem Identification :
- Identify the problem
- Determine the objective of the research
- Determine scope and assumptions.

Literature Study :
- Risk
- Risk Management
- Failure Modes and Effect Analysis (FMEA)
- ISO/DIS 45001:2017 clause 6

Data Collection and Analysis :
- The manufacturing process of Cement Wagon
- FMEA
- Current management system
- Gap analysis between the current management system and ISO/DIS 45001:2017

Conclusion and Recommendation :
- Conclusion to the objectives
- Recommendation for the future research

Figure 3.1 Research Framework

1.2 Description of Research Framework

3.2.1 Initial Observation

As a manufacturing company who produces heavy equipment product, there are many manufacturing process that has high probability of accident. The observation begin by conducting the observation directly to the factory. In the factory, there are many machines that require more supervision from the leader in order to reduce the probability of the accident. There are no analysis about risk identification before. To avoid any unnecessary accident, analysis about the risk assessment is need to be done.

3.2.2 Problem Identification

In this research, the main problem is to reduce accident rate. In this condition, the company must implement a various method and then make a proper planning in order to avoid accident occurred. This step is conducted to understand the problems focused on initial observation. The first thing to do in problem identification is to define the problem statements because they are the base of this research which will lead the research to the main purpose in conducting the research.

After the problem background has been determined, the objective of the research are elaborated. Clear explanations of problem statement, scope and assumptions are provided in Chapter 1.

3.2.3 Literature Study

This step used to support the research by using a reliable reference and guide to solve the existing problems. Several literature that is used as the references are Risk Management, Failure Modes and Effect Analysis, and ISO/DIS 45001:2017. While the literature study used to help the researcher to provide clear theoretical background, it also used to provide materials that related to the research in order to help the reader understands the fundamentals of the theory of this research.

3.2.4 Data Collection and Analysis

In this step, all the data that collected from various source such as from GA & ESR department, interview, and the production planning department are going to be shown. The data collected include:

- Accident data in 2016
- Risk Assessment
- Current management system

The data analysis include:

- Gap analysis between existing system and ISO/DIS 45001:2017
- FMEA
- Linkage between improving the existing management system and FMEA result

The accident data was collected with the help GA & ESR department. The gap analysis is done with the help of BMD department. The FMEA is done by consulting the researcher analysis to the GA & ESR department. So, in this research the analysis was made with the assistance of professional workers.

3.2.5 Conclusion and Recommendation

After finish in data collection and analysis, the next step is drawing conclusion from the data given based on the literature study to fulfill the research objective and answers the problem statements. Then, recommendation will be given to improve the current system or condition in the work place.

3.3 Detail Research Framework

The detail framework of research methodology is shown in Figure 3.2 below. This figure shows the detail of the research process. The research starts after the researcher has known the existing problem in PT. XYZ. The next step of the research is getting to know PT. XYZ OH&S management systems. Currently, PT. XYZ already has OHSAS 18001:2007 certification. After knowing the PT. XYZ OH&S management systems works, the next step in the data collection will be collecting the accident data that happens in 2016 and what new product that has the most accident in the 2016. Then, after collecting the accident data needed for the

research the next step is to discuss with the HSE staff about the emergency scenario for each process.

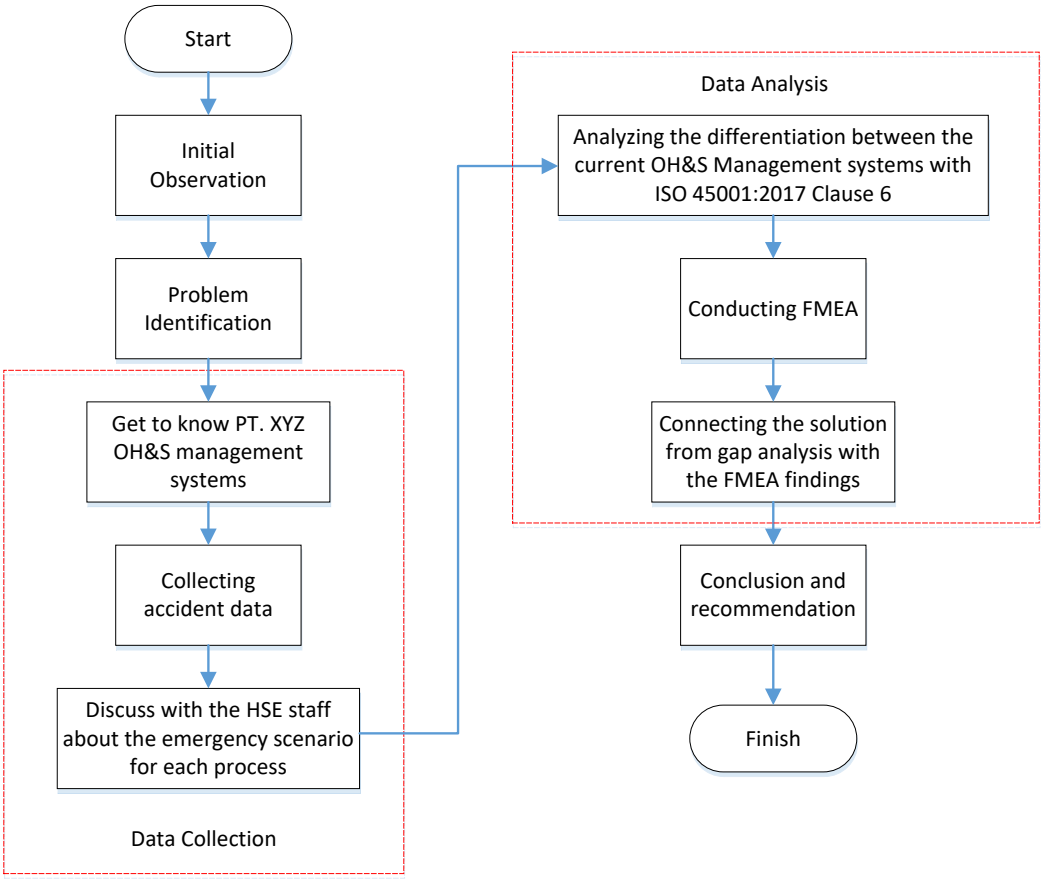


Figure 3.2 Detail Research Framework

For the data analysis, the first step is to analyze the differentiation between the current OH&S management systems with ISO 45001:2017 clause 6. The next step in the data analysis phase is to conduct FMEA and make a key performance index for the hazard performance control grade of PT. XYZ. The final step is to connect the solution in fulfilling the gap between the current OH&S management systems and the ISO 45001:2017 with the FMEA's finding. After that, researcher needs to conclude the research and give recommendation for PT. XYZ and for the future research.

CHAPTER IV
DATA COLLECTION AND ANALYSIS

4.1 Data Collection

In this section, all of the data that going to be analyzed will be shown. The data consist of brief explanation PT. XYZ profile, accident data in the past 2016, and emergency scenario for each manufacturing process of cement wagon.

4.1.1 Company Profile

Established in 1983, PT. XYZ is a leading company in the manufacturing of heavy equipment in Indonesia. Heavy equipment produced by PT. XYZ is already used in many fields, ranging from Mining (Mining Trucks, Heavy Equipment Carrier Cars, Truck Coal, Truck Trailer), Plantation and Forestry (Compost Turner Machine, Tool Makers Compost, Machine Compost, Turner Palm Oil), Construction (Truck Mixer, Car Dump Truck, Body Tank Cement, Bulk Tanker Cement Body, Concrete Mixer), Industry (Truck Trailer, Beating Wing Box, Forklift, Truck Box, Truck Wing Box), Oil and gas (Hydraulic Pump), Marine and Shipbuilding. Given solution specific to the needs of customers ranging from the provision of new equipment to the consultation comes at an attractive price and quality assurance from PT. XYZ. The services is also to support after-sales to maximize the productivity of its clients. PT. XYZ clients are now scattered in various regions in Indonesia and also in many countries around the world.

PT. XYZ has two main components in the operations, namely the Engineering Design and Manufacturing. Activities from the Design Engineering is designing and calculating all aspects of a product, while the activity of manufacturing is running all the processes required to make the products design from Design Engineering can be realized. However, there is the main component that also important, namely Marketing, because the products of PT. XYZ sold in the international market. Marketing tasked with carrying out a study on the consumer market and are looking for markets where these products can be sold. To be able to produce a quality product PT. XYZ to develop a product by bringing together the

three components. Broadly speaking, the products manufactured by PT. XYZ based customize and job order. Customize job order is special requests from customers who want to order, while job order is a request from the customer about the product ever made by PT. XYZ before, so there is no demand for specific design of the product to be ordered.

From early 2016, PT. XYZ got misfortune. There are many accidents occurred in the specific work area. Thus, PT. XYZ suffered capital loss to make up for the accident. Table 4.1 below will elaborate the accident that occurred in the 2016.

Table 4.1 Accident Data in Cement Wagon Manufacturing Process of PT. XYZ in 2016

No	Description	Effect	Time of Accident	In Process	Loss
1	Bracket manhole exploded	Property damage	March	11	Property damage
2	Operator's head collided with workpiece	Injury	May	7	LTI 1 day
3	Operator's fingers crushed	Injury	August	14	LTI 1 week
4	Operator's hand got cut	Injury	September	8	LTI 2 weeks
5	Operator's got slipped while painting workpiece	Injury	October	16	LTI 1 week

Note:

- LTI: Lost Time Injury (the victim of each LTI in this data is 1 person)
- Time: Time of accident occurred in the company
- Process: Specific cement wagon's manufacturing process that involved in accident (check figure 4.1)

4.1.2 Emergency Scenario from Each Steps

Before conducting FMEA for the cement wagon, the manufacturing process of cement wagon and emergency scenario for each process should be defined. Figure 4.1 will explain about the flow chart of cement wagon manufacturing process. Emergency scenario is important to conduct because if researcher does not know the potential emergency scenario of each process, the hazard performance control rate can't be evaluated.

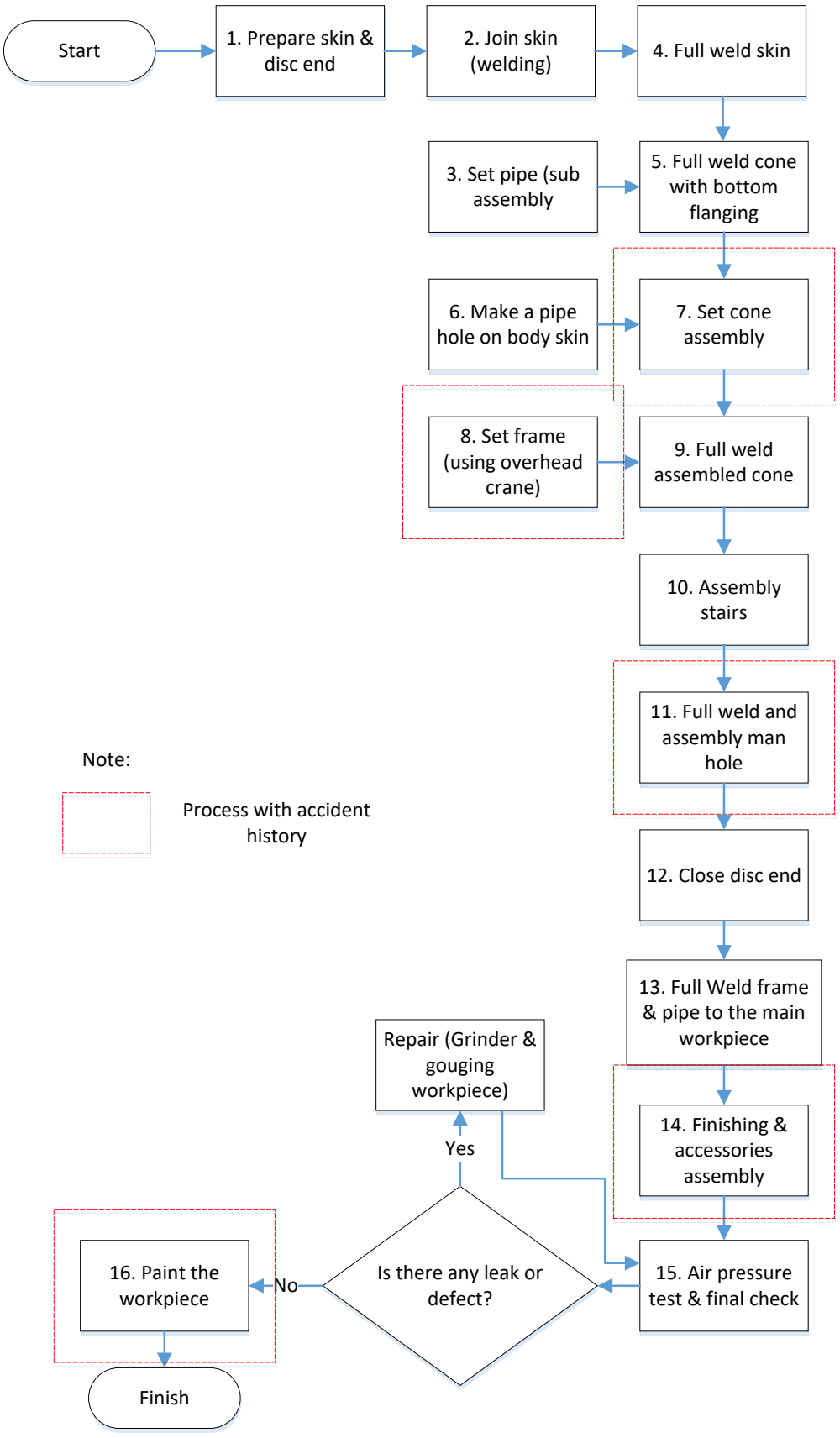


Figure 4.1 Flow Chart Manufacturing Process of Cement Wagon with Accident History

In the Figure 4.1, the manufacturing process is being elaborated and the process that has accident history will be highlighted. For the RPN calculation, Table 2.2, 2.3, and 2.4 should be used as reference. For example in the Table 4.2 operation no.1, one of the failure mode is “workpiece slammed” got 4 in possibilities, 4 in severity, and 2 in detectability. The reason is the risk possibilities is still low (1:4500), moderate severity (considering loss from accident), and the risk is easy to detect.

Table 4.2 Emergency Scenario From Each Step

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
1	Preparation skin & disc end	Operator got hit by swings of the workpiece	Injury / bruises / fractures	4	6	3	72
		Other labour got hit by moving wokpiece	Injury / bruises / fractures	2	6	4	48
		Material hiting the wall or other items	Property damage	2	4	5	40
		Workpiece Slammed	Property damage	4	4	2	32
2	Join skin (Welding)	Exposed to welding sparks	Burns	4	6	5	120
		The light emitted from the welding process is too bright	eye injury	4	4	5	80
		Electrocuted	Injury	3	4	6	72
3	Setting pipe (sub assembly)	The work position is not ergonomic	Musculoskeletal disorders	4	4	3	48
		The pipe lockdown is not locked tightly	Property damage	2	3	2	12
		Leak	Property damage	2	3	2	12

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
4	Full weld skin	Electrocuted	Injury / Fatality	4	6	5	120
		Exposed to welding sparks	Injury / cuts	4	4	5	80
		Welding sparks got on the other labour	Burns	3	5	4	60
		The work position is not ergonomic	Musculoskeletal disorders	4	4	3	48
		Workpiece positioning is not fit to JIG Fixture	Property damage	4	4	3	48
		Welding fumes released into the air	the degradation of air quality	5	3	3	45
		Fall from the high place	Injury / bruises / fractures	4	5	2	40
		Operator got sleepy	Injury	2	5	3	30
		Exposed to welding smoke	Degradation of seeing ability	2	4	3	24
		the light emitted from the welding process is too bright	eye injury	2	3	2	12
5	Full weld cone with bottom flanging	Electrocuted	Injury / Fatality	4	6	5	120
		the light emitted from the welding process is too bright	eye injury	3	6	5	90
		Exposed to welding sparks	Burns	4	4	5	80
		Exposed to welding smoke	Degradation of seeing ability	4	4	4	64
6	Make pipe hole on body skin	Argon gas explosion	Injury	3	5	4	60
		Health problems due to hot work environment	Dehydration, Fatigue	3	4	5	60

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
6	Make pipe hole on body skin	Operator got hit by hot workpice or material	Bruise	4	6	2	48
		The work position is not ergonomic	Musculoskeletal disorders	4	4	3	48
		Fire due to leakage of gas hose	Burns	4	5	2	40
		operator got sleepy	Injury	3	4	3	36
		The residue of the iron scaterred	the degradation of ground water quality	3	4	3	36
		Operator slipped whie handling the results of the pieces	Injury	2	5	3	30
		Fire due to leakage of gas hose	Property damage	2	3	4	24
		Filter on fire	the degradation of air quality	2	4	3	24
			Property damage	2	4	3	24
		Gas produced form cuts	Degradation of operator's respiratory function	2	4	2	16
7	Setting cone assembly	Limited work space	High chance Injury	4	4	4	64
		The work position is not ergonomic	Musculoskeletal disorders	4	4	3	48
		operator slipped whie handling the pieces	Injury	2	3	2	12
8	Setting frame (Using over head crane)	Hook got loose resulting material falls on the operator	Injury / bruises / fractures	3	6	3	54
		Hook got loose resulting material falls	Property damage	3	4	2	24

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
8	Setting frame (Using over head crane)	Crane's sling broke up so that the material falls	Property damage	2	4	3	24
		Crane's sling broke up so that the material falls on the operator	Injury / bruises / fractures	2	4	3	24
		Crane's hook got loose so that the material slammed	Property damage	2	2	3	12
9	Full weld assembled cone	Work environment is filled with smoke	the degradation of air quality	3	6	5	90
		Lack of lighting	Tired eyes	4	4	5	80
		Limited work space	High chance Injury	4	4	4	64
		Lack of oxigen	Degradation of operator's respiratory function	3	4	5	60
		The work environment is hot	Dehydration, Fatigue	2	6	4	48
10	Assembly stairs	Material defect	Injury / property damage	5	6	3	90
11	Full weld and assembly man hole	Bolt broken when pressure testing	Property damage	7	9	8	504
		Hook does not work properly	Property damage	4	6	7	168
		Leak	Property damage	2	8	8	128
		Electrocuted	Injury / Fatality	4	6	5	120
		Exposed to welding smoke	Degradation of seeing ability	5	6	3	90
		Cracks in the welding area	Property damage	3	7	4	84
		Exposed to welding sparks	Burns	4	4	5	80
		the light emitted from the welding process is too bright	eye injury	4	4	5	80

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
12	Close disc end	Leak	Property damage	5	5	4	100
		Cracks in the welding area	Property damage	2	2	3	12
13	Welding frame & pipe to the main workpiece	Exposed to welding smoke	Degradation of seeing ability	4	4	4	64
		the light emitted from the welding process is too bright	eye injury	3	6	5	90
		Electrocuted	Injury / Fatality	4	6	5	120
		Exposed to welding sparks	Burns	3	4	5	60
14	Finishing & accessories	Fall from the high place	Fatality	4	5	2	40
15	Air Pressure Test & final check	Hose extension leaks	the degradation of air quality	2	7	5	70
		Health problems due to hot work environment	Dehydration, Fatigue	3	4	5	60
		Valve's seal exploded	Injury	2	7	4	56
		Bracket man hole leaks	the degradation of air quality	2	7	4	56
		The detached hose hurting the operator	Injury	4	6	2	48
		The pressure is too high	Explosion	2	7	3	42
		Lack of clean air (full of cement)	Respiratory disorder	7	6	1	42
		Noise from testing	Hearing loss	5	4	2	40
		Fall from the high place	Fatality	4	5	2	40
		Slipped when attaching hose	Injury	3	6	2	36
		operator's hands exposed to the cement	Skin irritation	6	6	1	36

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
16	Painting	Paint dust released to the air	the degradation of air quality	6	5	3	90
		Fall from the high place	Injury	7	6	2	84
		Operators get pinched by workpiece	Injury	7	6	2	84
		Exposed to paint dust	Respiratory disorder	6	6	2	72
		Health problems due to hot work environment	Dehydration, Fatigue	3	4	5	60
		Thinner fume released to the air	the degradation of air quality	5	5	2	50
		The work position is not ergonomic	Musculoskeletal disorders	4	4	3	48
		Exposed to thinner fume	Respiratory disorder	7	6	1	42
		Paint spilled on the floor	the degradation of ground water quality	4	4	2	32
		Paint waste	the degradation of ground water quality	3	5	2	30
		Fall from the ladder	Injury	2	5	2	20
17	Repair / rework						
	A. Grinder process	Dangerous gasses in the working area (in the tank)	Poisoned	4	5	5	100
		Dangerous gasses in the working area (in the tank)	Explosion	4	5	5	100
		Dangerous gasses in the working area (in the tank)	Fire	4	5	5	100
		Electrocuted (if using electrical grinder)	Injury, fatality	4	6	5	120

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
17	A. Grinder process	Operator's hand got hit by grinder	Cuts	5	2	4	40
		Residual powder of grinder got into the operator's eyes	eye injury	6	2	3	36
		Got hit by detached air hose	Injury	4	2	4	32
		Exposed to grinder's spark	Burns	5	2	3	30
		Over air pressure (if using pneumatic grinder)	Injury	5	2	3	30
		Over air pressure (if using pneumatic grinder)	Hearing loss	5	2	3	30
		Grinder residue scattered	the degradation of ground water quality	5	2	3	30
		Noise from the grinder	Hearing loss	4	2	3	24
		The grinder falls on the foot	Injury	4	1	4	16
		Grinder vibration	Injury, numbness	5	1	3	15
	B. Gouging process						
	a. The process of leveling material / component by beating it with a hammer	Health problems due to environment noise	Hearing loss	3	2	2	12
		Hammer got bounced	Injury, bruise	2	2	3	12

Table 4.2 Emergency Scenario From Each Step *(Cont'd)*

No	Process Description	Potential Failure Mode	Potential Effect of Failure	Risk Assessment			
				(a) Possibilities	(b) Severity	(c) Detectability	Risk Priority Number (RPN) (a x b x c)
17	b. Destroy the current finished goods (welded workpiece) to make a new one	Health problems due to environment noise	Hearing loss	4	6	5	120
		Exposed to the fire sparks	Burns	4	4	5	80
		Electrocuted	Fatality	3	2	3	18
		Fires due to fire sparks on flammable materials	Property damage	3	2	3	18
		Got hit by workpiece	Injury	2	3	2	12
		Health problems due to hot work environment	Dehydration, Fatigue.	2	2	3	12

As mentioned in sub chapter 3, The HSE staffs is responsible to assess the RPN. The calculation of RPN will be based on the severity, possibilities, and detectability scoring criteria. Then, the score of each criteria will be multiplied to get the RPN score.

In the table 4.2, there are a lot of similarity of potential failure mode among the steps. The main reason is because among those steps there is a similarity like welding process and working in the high place. Thus, the only difference among them is the function of each steps towards the product.

4.2 Data Analysis

In this section, the data that has been gathered will be analyzed further to solve the existing problem. This section consist of explanation ISO 45001 changes, FMEA for cement wagon, and the analysis to reducing accident rate.

4.2.1 Gap analysis between current company management systems with clause 6 of ISO 45001:2017

Table 4.3 Explanation about the ISO 45001 changes

6. Planning	
6.1 Actions to address risks and opportunities	This clause has been revised and combines some of the clauses of OHSAS 18001 resulting in a broader concept that includes opportunities and measures of effectiveness.
6.1.1 General	
6.1.2 Hazard identification and assessment of OH&S risks	This clause and its sub clauses offer all the requirements for identifying hazards and assessing OH&S risks, and in general, this process is the same as required in the OHSAS 18001 standard. In order for an OHSMS to work effectively a company has to identify all the risks presented by its processes and then assess the risk in the hazards.
6.1.2.1 Hazard Identification	ISO 45001 requires a company to design the identification process in a proactive manner based on the possible risks that may arise from the operations of the company. This identification of risks and hazards must take into account the following: • Routine and non-routine activities • Emergency situations • People who are involved • Other issues that include the design of the workplace • Changes in the company • Changes in information about the dangers • The incidents of the past • Social factors of the company

Source: PECB, 2016

Table 4.3 Explanation about the ISO 45001 changes (Cont'd)

6.1.1 General	
6.1.2.2 Assessment of OH&S risks and other risks to the OH& Management system	The risk assessment still requires that the risks of hazards are identified and lead to the prevention of occupational hazards and its operations. These criteria must be defined by the company, as it will be different from one company to another.
6.2 OH&S objectives and planning to achieve them	1. Set goals and objectives as part of the planning process. 2. Word the goals and objectives clearly. 3. Goals and objectives must be realistic. 4. Accomplishing goals and objectives must be under the responsible person's influence or control. 5. Objectives must be assigned to someone. 6. Completion dates must be established for each objective and goal.

Source: PECB, 2016

Table 4.3 explain the difference between ISO 45001:2017 (later on will be referred as management system or MS) and OHSAS 18001:2007. In the new MS, the planning for the reducing accident rate will only be define the clause from the OHSAS 18001:2007 more elaborate.

Table 4.4 Gap analysis between PT. XYZ management systems and ISO 45001:2017

Criteria of clause 6		Done by company?
6. Planning (title only)		-
6.1 Actions to address risks and opportunities	This clause has been revised and combines some of the clauses of OHSAS 18001 resulting in a broader concept that includes opportunities and measures of effectiveness.	YES
6.1.1 General		-
6.1.2 Hazard identification and assessment of OH&S risks	This clause and its sub clauses offer all the requirements for identifying hazards and assessing OH&S risks, and in general, this process is the same as required in the OHSAS 18001 standard. In order for an OHSMS to work effectively a company has to identify all the risks presented by its processes and then assess the risk in the hazards.	YES
6.1.2.1 Hazard Identification	ISO 45001 requires a company to design the identification process in a proactive manner based on the possible risks that may arise from the operations of the company. This identification of risks and hazards must take into account the following:	-
	• Routine and non-routine activities	YES
	• Emergency situations	YES
	• People who are involved	NO
	• Other issues that include the design of the workplace	NO
	• Changes in the company	NO
	• Changes in information about the dangers	YES
	• The incidents of the past	NO
	• Social factors of the company	NO
6.1.2.2 Assessment of OH&S risks and other risks to the OH& Management system	The risk assessment still requires that the risks of hazards are identified and lead to the prevention of occupational hazards and its operations. These criteria must be defined by the company, as it will be different from one company to another.	YES
6.2 OH&S objectives and planning to achieve them	1. Set goals and objectives as part of the planning process. 2. Word the goals and objectives clearly. 3. Goals and objectives must be realistic. 4. Accomplishing goals and objectives must be under the responsible person's influence or control. 5. Objectives must be assigned to someone. 6. Completion dates must be established for each objective and goal.	YES

Table 4.5 Evidence of The Criteria That have been Implemented in PT. XYZ

No.	Criteria	Evidence	Approved by
6.1	Actions to address risks and opportunities	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ
6.1.2	Hazard identification and assessment of OH&S risks	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ
6.1.2.1	Routine and non-routine activities	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ
6.1.2.1	Emergency situations	Emergency Evacuation Map & Short Induction for Guest or New Employee	Head of GA & ESR Dept.
6.1.2.1	Changes in information about the dangers	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ
6.1.2.2	Assessment of OH&S risks and other risks to the OH& Management system	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ
6.2	OH&S objectives and planning to achieve them	PT.XYZ Green Company Project Handbook	Head of Board of Directors of PT. XYZ

For the clause 6 of ISO 45001:2017, there are no major improvement from OHSAS 18001:2007. So, the company already implemented most of the ISO 45001:2017 and only need little work in implementing the new management systems in order to complete clause of ISO 45001:2017. The description of the clause 6 criteria is using professional ISO auditor standard (in this case it is PECB). So, by completing PECB's clause 6 criteria, PT. XYZ can perform internal auditing for clause 6 of ISO 45001:2017 before applying for the ISO 45001:2017.

Based on the table 5.4 there are 5 criteria that did not fulfilled by PT. XYZ, which are;

1. Define the people who are involved in risk control
2. Define a reliable design (layout, product, and workplace) to minimize the risk

3. Company goals to face changes when producing new product and reducing the accident possibilities
4. Documenting the accident in FMEA
5. Create strategy for better risk control while following social trends.

These criteria needs explanation thoroughly so that it will answer all of the auditor's questions regarding the ISO 45001:2017. Complete explanation will be explained below.

1. Define the people who are involved in accident risk control

To make the risk control in a company easier, the company needs to assign a team that will plan, do, check, and act in order to reduce the accident rate. In this case, the team should consist of at least 3 members with its own job description. The job description for each members should meet the company goals which is zero accident in a year.

To help this team to finish its task, the company should also socialize to all of the workers to succeed the programs. It also means that to assign the leader of the labors to take care its subordinate. Then, the foreman will be responsible for the leaders. Then, supervisor will be responsible for the foremen. Then, the managers of manufacturing department will be responsible for the supervisors. By applying this hierarchy, the workers will have to have sense of belonging and has its clear responsibility.

Beside of the manufacturing department, the quality assurance (QA) and quality control (QC) department will also play a vital role in minimizing the accident rate. Because, most of the accident happened because lack of inspection before conducting the job. Currently, PT. XYZ is lack of people to conduct whole inspection. The bad result of it is inevitable. To avoid further mess, the QA and QC department needs to come up with updated methods in conducting inspection in order to minimize the possibility of defect either in the materials or in the products that may resulting in accident.

2. **Define a reliable design (layout, product, and workplace) to minimize the risk**

Because of PT. XYZ company is has a centered hierarchy of control, the problem solving of each problem really takes its time. So, even though the company can solve the problem, it needs approval from the central in order to execute the solution of the problem. For example, there is a problem with the machine layout design. It does not fit to the new product adjustment. Because of the hierarchy system, the solution needs to have an approval from the higher ups to implement it.

For the solution to the problem, the central needs to give some authority to the company so the solution can take an action immediately. The department that responsible for this matter is engineering department. Engineering department is responsible to create new design that include layout, product, workplace, etc. to satisfy the new product's needs. The design also needs to consider many aspect like environmental, ergonomics, financial, etc. before implementing it.

3. **Company strategy to face changes when producing new product and reducing the accident possibilities**

PT. XYZ needs to make a goals that can afford to reduce the accident rate. The strategy can be a simple one like SMART method. Currently, the company goal in reducing accident rate is to make 2016 zero accident. But, sadly this goal has been broken in March 2016.

The point is, to make a strategy to face a change both of employers and employees need to be ready for a change. Changes in here is not limited to structural changes but also the company strategy that needs to be flexible. If the people is not ready for a change, there will be a lot investment that needed to invest in here. Because, if the employees are unfortunately not ready, the manager needs to find a replacement to fill the gap.

4. Documenting the accident in FMEA

Accident is an event that every company want to avoid. Because, it will cause negative effect to the company. But, even though accident is bad, the company still need to record the accident in order to come up with strategies to avoid the accident being repeated in the future.

PT. XYZ has a record of accident data that ever occurred in the company. But, the data does not consist in what specific process the accident occurred. So, to make the record more complete, the company needs to add a column of data in the FMEA that show history of accident in specific process.

5. Create strategy for better accident risk control while following social trends.

In 2016, the trend for mining industry is decreased. Thus, the market of PT. XYZ is getting smaller. To make the company healthy, the company needs to add more specialties in making new products so the market will be broaden. New market means new product. Thus, with the new product that has been added to company specialties, there will be an increase in accident rate.

PT. XYZ is currently conducting FMEA once a year. While usually a company needs to conduct FMEA at least thrice a year to cover for the new product. So, to solve the problem the company needs to conduct FMEA at least thrice a year or every new products being ordered by its clients.

4.2.2 Failure modes effect analysis for cement wagon

FMEA is a tool that used to identify the risk that may happen in a company in order to prevent the accident to occur in a company. In this case FMEA is used to identify the risk and its hazard prevention and then comparing the company current management system (OHSAS 18001:2007) with the new ISO 45001:2017.

Table 4.6 PT. XYZ Original FMEA Format

Process description		Category	Applicable Regulation	Failure mode	Effect of failure	Operation Condition	Existing Risk Control	Risk		
								Possibilities	Severity	Risk Priority Number (RPN)
Process FMEA of Cement wagon										
Material handling										
a.	Material handling with over head crane	R	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1985	Hook got loose resulting material falls	Property damage	N	Quality inspection	4	4	16
			Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1986	Hook got loose resulting material falls on the operator	Injury / bruises / fractures	N	Quality inspection	4	6	24
			Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1987	Crane's sling broke up so that the material falls	Property damage	Ab	Routine inspection and greasing	2	4	8
			Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1988	Crane's sling broke up so that the material falls on the operator	Injury / bruises / fractures	Ab	Routine inspection and greasing	2	6	12
			Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1989	Crane's hook got loose so that the material slammed	Property damage	N	Safety latch installed properly	2	4	8
			Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1990	The chain broken so that the material falls	Property damage	Ab	Inspect chain's condition	2	6	12

Based on the table 5.3, PT. XYZ's FMEA format has fulfilled some of the clause 6. Therefore, to achieve ISO 45001 the format needs to update. The original PT. XYZ format is enough to be called FMEA analysis. But, it lacks many elements such as detectability, history of accident, and confirmation of hazard prevention application by company.

Table 4.7 Proposed FMEA Format (example)

Operation No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
1	Preparation skin & disc end	R	Operator got hit by swings of the workpiece	Injury / bruises / fractures	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Training Crane Usage	4	6	3	72	-	YES	L
			Other labour got hit by moving wokpiece	Injury / bruises / fractures	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1994	Make machine's perimeter line	2	6	4	48	-	YES	L
			Material hiting the wall or other items	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1993	Wall shielded	2	4	5	40	-	YES	L
			Workpiece Slammed	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1991	Inspect magnet lifting condtion	4	4	2	32	-	YES	L

In the table 5.4, there are new columns that added in the FMEA. The reason is to fulfil the requirement of ISO/DIS 45001:2017 clause 6 which is to show the category (routine or non-routine), applicable regulation, operation condition (normal, abnormal, or emergency), history of accident, and if the risk priority value is very big, FMEA needs to add another column to explain the action taken in order to reduce RPN value as low possible.

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
1	Preparation skin & disc end	R	Operator got hit by swings of the workpiece	Injury / bruises / fractures	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Training Crane Usage	4	6	3	72	-	YES	L
			Other labor got hit by moving workpiece	Injury / bruises / fractures	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1994	Make machine's perimeter line	2	6	4	48	-	YES	L
			Material hitting the wall or other items	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1993	Wall shielded	2	4	5	40	-	YES	L
			Workpiece Slammed	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1991	Inspect magnet lifting condition	4	4	2	32	-	YES	L
2	Join skin (Welding)	R	Electrocuted	Injury	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Grounding welding machine	4	6	5	120	-	YES	L
			Exposed to welding sparks	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
			The light emitted from the welding process is too bright	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	4	6	72	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
3	Setting pipe (sub assembly)	R	The work position is not ergonomic	Musculos keletal disorders	N	UU No.01 Tahun 1970	Stretching or SKJ gymnastic before work, material or workpiece over 10kg are not allowed to lift manually	4	4	3	48	-	YES	L
			The pipe lockdown is not locked tightly	Property damage	N	UU No.01 Tahun 1970	Inspection	2	3	2	12	-	NO	L
			Leak	Property damage	N	UU No.01 Tahun 1970	Inspection	2	3	2	12	-	NO	L
4	Full weld skin	R	Electrocuted	Injury / Fatality	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Grounding welding machine	4	6	5	120	-	YES	L
			Exposed to welding sparks	Injury / cuts	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
			Welding sparks got on the other labor	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	5	4	60	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
4	Full weld skin	R	The work position is not ergonomic	Musculoskel etal disorders	N	UU No.01 Tahun 1970	Stretching or SKJ gymnastic before work, material or workpiece over 10kg are not allowed to lift manually	4	4	3	48	-	YES	L
			Workpiece positioning is not fit to JIG Fixture	Property damage	N	UU No.01 Tahun 1970	Training	4	4	3	48	-	YES	L
			Welding fumes released into the air	the degradation of air quality	N	PP No.41 Tahun 1999	Measuring air ambient quality	5	3	3	45	-	NO	L
			Fall from the high place	Injury / bruises / fractures	N	Permenaker No. 09 tahun 2016	SOP of working in the high place	4	5	2	40	-	YES	L
			Operator got sleepy	Injury	Ab	UU No.01 Tahun 1970	Make sure the operator has enough rest	2	5	3	30	-	YES	L
			Exposed to welding smoke	Degradation of seeing ability	N	PP41/1999	Personal Protective Equipment	2	4	3	24	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
4	Full weld skin	R	the light emitted from the welding process is too bright	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	2	3	2	12	-	YES	L
5	Full weld cone with bottom flanging	R	Electrocuted	Injury / Fatality	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Grounding welding machine	4	6	5	120	-	YES	L
			the light emitted from the welding process is too bright	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	6	5	90	-	YES	L
			Exposed to welding sparks	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
			Exposed to welding smoke	Degradation of seeing ability	N	PP41/1999	Personal Protective Equipment	4	4	4	64	-	YES	L
6	Make pipe hole on body skin	R	Argon gas explosion	Injury	E	UU No.01 Tahun 1970	Regulator	3	5	4	60	-	NO	L
			Health problems due to hot work environment	Dehydration, Fatigue	N	UU No.01 Tahun 1970	Educate dehydration, supply gallons	3	4	5	60	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
6	Make pipe hole on body skin	R	Operator got hit by hot workpiece or material	Bruise	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	6	2	48	-	YES	L
			The work position is not ergonomic	Musculoskel etal disorders	N	UU No.01 Tahun 1970	Stretching or SKJ gymnastic before work, material or workpiece over 10kg are not allowed to lift manually	4	4	3	48	-	YES	L
			Fire due to leakage of gas hose	Burns	E	UU No.01 Tahun 1970	Training for emergency situation	4	5	2	40	-	YES	L
			operator got sleepy	Injury	Ab	UU No.01 Tahun 1970	Make sure the operator has enough rest	3	4	3	36	-	YES	L
			The residue of the iron scattered	the degradation of ground water quality	N	PP 82/2001	Area cleaning	3	4	3	36	-	NO	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
6	Make pipe hole on body skin	R	Operator slipped while handling the results of the pieces	Injury	Ab	UU No.01 Tahun 1970	Personal Protective Equipment	2	5	3	30	-	YES	L
			Fire due to leakage of gas hose	Property damage	E	UU No.01 Tahun 1970	Inspection	2	3	4	24	-	YES	L
			Filter on fire	the degradation of air quality	E	PP No.41 Tahun 1999	Inspection	2	4	3	24	-	NO	L
			Filter on fire	Property damage	E	UU No.01 Tahun 1970	Inspection	2	4	3	24	-	NO	L
			Gas produced form cuts	Degradation of operator's respiratory function	N	UU No.01 Tahun 1970	Mask	2	4	2	16	-	YES	L
7	Setting cone assembly	R	Limited work space	High chance Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment, Air circulator	4	4	4	64	May	YES	L
			Crane's hook got loose so that the material slammed	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Safety latch installed properly	2	2	3	12	-	NO	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
7	Setting cone assembly	R	operator slipped while handling the pieces	Injury	Ab	UU No.01 Tahun 1970	Personal Protective Equipment	2	3	2	12	-	YES	L
8	Setting frame (Using over head crane)	R	Hook got loose resulting material falls on the operator	Injury / bruises / fractures	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Quality inspection	3	6	3	54	-	NO	L
			Hook got loose resulting material falls	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Quality inspection	3	4	2	24	-	NO	L
			Crane's sling broke up so that the material falls	Property damage	Ab	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Routine inspection and greasing	2	4	3	24	-	YES	L
			Crane's sling broke up so that the material falls on the operator	Injury / bruises / fractures	Ab	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Routine inspection and greasing	2	4	3	24	September	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
8	Setting frame (Using over head crane)	R	Crane's hook got loose so that the material slammed	Property damage	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1992	Safety latch installed properly	2	2	3	12	-	NO	L
9	Full weld assembled cone	R	Work environment is filled with smoke	the degradation of air quality	N	PP No.41 Tahun 1999	N-95 Mask, Blower utilization	3	6	5	90	-	YES	L
			Lack of lighting	Tired eyes	N	UU No.01 Tahun 1970	Lamp installation	4	4	5	80	-	YES	L
			Limited work space	High chance Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment, Air circulator	4	4	4	64	-	YES	L
			Lack of oxygen	Degradation of operator's respiratory function	Ab	UU No.01 Tahun 1970	Work instruction of welding	3	4	5	60	-	YES	L
			The work environment is hot	Dehydration, Fatigue	N	UU No.01 Tahun 1970	Educate dehydration, supply gallons	2	6	4	48	-	YES	L
10	Assembly stairs	R	Material defect	Injury / property damage	Ab	UU No.01 Tahun 1970	Inspection	5	6	3	90	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
11	Full weld and assembly man hole	R	Bolt broken when pressure testing	Property damage	Ab	UU No.01 Tahun 1970	Change design	7	9	8	504	March	NO	H
			Hook does not work properly	Property damage	Ab	UU No.01 Tahun 1970	Inspection	4	6	7	168	-	NO	M
			Leak	Property damage	Ab	UU No.01 Tahun 1970	Inspection	2	8	8	128	-	YES	M
			Electrocuted	Injury / Fatality	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Grounding welding machine	4	6	5	120	-	YES	L
			Exposed to welding smoke	Degradation of seeing ability	N	PP41/1999	Personal Protective Equipment	5	6	3	90	-	YES	L
			Cracks in the welding area	Property damage	Ab	UU No.01 Tahun 1970	Inspection	3	7	4	84	-	YES	L
			Exposed to welding sparks	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
			the light emitted from the welding process is too bright	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
12	Close disc end	R	Leak	Property damage	Ab	UU No.01 Tahun 1970	Inspection	5	5	4	100	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
12	Close disc end	R	Cracks in the welding area	Property damage	Ab	UU No.01 Tahun 1970	Inspection	2	2	3	12	-	YES	L
13	Welding frame & pipe to the main workpiece	R	Exposed to welding smoke	Degradation of seeing ability	N	PP41/1999	Personal Protective Equipment	4	4	4	64	-	YES	L
			the light emitted from the welding process is too bright	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	6	5	90	-	YES	L
			Electrocuted	Injury / Fatality	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Grounding welding machine	4	6	5	120	-	YES	L
			Exposed to welding sparks	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	4	5	60	-	YES	L
14	Finishing & accessories	R	Fall from the high place	Fatality	N	Permenaker No. 09 tahun 2016	SOP of working in the high place	4	5	2	40	August	YES	L
15	Air Pressure Test & final check	R	Hose extension leaks	the degradation of air quality	Ab	PP No.41 Tahun 1999	N-95 Mask	2	7	5	70	-	NO	L
			Health problems due to hot work environment	Dehydration, Fatigue	N	UU No.01 Tahun 1970	Educate dehydration, supply gallons	3	4	5	60	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
15	Air Pressure Test & final check	R	Valve's seal exploded	Injury	E	UU No.01 Tahun 1970	Work instruction welding	2	7	4	56	-	YES	L
			Bracket man hole leaks	the degradation of air quality	Ab	PP No.41 Tahun 1999	N-95 Mask	2	7	4	56	-	NO	L
			The detached hose hurting the operator	Injury	N	UU No.01 Tahun 1970	Make sure the hose clamp is tied	4	6	2	48	-	YES	L
			The pressure is too high	Explosion	E	UU No.01 Tahun 1970	Pressure gauge	2	7	3	42	-	YES	L
			Lack of clean air (full of cement)	Respiratory disorder	N	UU No.01 Tahun 1970, Kep Men 01/Men/1999	N-95 Mask, Blower utilization	7	6	1	42	-	NO	L
			Noise from testing	Hearing loss	N	UU No.01 Tahun 1970	Earplug	5	4	2	40	-	YES	L
			Fall from the high place	Fatality	N	Permenaker No. 09 tahun 2016	SOP of working in the high place	4	5	2	40	-	YES	L
			Slipped when attaching hose	Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	3	6	2	36	-	YES	L
			operator's hands exposed to the cement	Skin irritation	N	UU No.01 Tahun 1970	Personal Protective Equipment	6	6	1	36	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
16	Painting	R	Paint dust released to the air	the degradation of air quality	N	PP No 41 tahun 1999	Funnel filtration	6	5	3	90	-	YES	L
			Fall from the high place	Injury	N	Permenaker No. 09 tahun 2016	SOP of working in the high place	7	6	2	84	October	YES	L
			Operators get pinched by workpiece	Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	7	6	2	84	-	YES	L
			Exposed to paint dust	Respiratory disorder	N	UU No.01 Tahun 1970, Kep Men 01/Men/1999	N-95 Mask, Blower utilization	6	6	2	72	-	NO	L
			Health problems due to hot work environment	Dehydration, Fatigue	N	UU No.01 Tahun 1970	Educate dehydration, supply gallons	3	4	5	60	-	YES	L
			Thinner fume released to the air	the degradation of air quality	N	PP No 41 tahun 1999	Funnel filtration	5	5	2	50	-	YES	L
			The work position is not ergonomic	Musculoskel etal disorders	N	UU No.01 Tahun 1970	Stretching or SKJ gymnastic before work, material or workpiece over 10kg are not allowed to lift manually	4	4	3	48	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
16	Painting	R	Exposed to thinner fume	Respiratory disorder	N	UU No.01 Tahun 1970, Kep Men 01/Men/1999	N-95 Mask, Blower utilization	7	6	1	42	-	NO	L
			Paint spilled on the floor	the degradation of ground water quality	N	Permenaker No. 09 Tahun 2010, Permenaker No.05/Men/1985, Perda Jabar No.10 Tahun 1995	Area cleaning	4	4	2	32	-	YES	L
			Paint waste	the degradation of ground water quality	N	PP No 82 tahun 2001, KepmenLH No 112 tahun 2003	Area cleaning	3	5	2	30	-	NO	L
			Fall from the ladder	Injury	N	Permenaker No. 09 tahun 2016	SOP of working in the high place	2	5	2	20	-	YES	L
17	Repair / rework													
	A. Grinder process	R	Dangerous gasses in the working area (in the tank)	Poisoned	N	UU No.01 Tahun 1970	SOP of working at confined space	4	5	5	100	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
17	A. Grinder process	R	Dangerous gasses in the working area (in the tank)	Explosion	N	UU No.01 Tahun 1970	SOP of working at confined space	4	5	5	100	-	YES	L
			Dangerous gasses in the working area (in the tank)	Fire	E	UU No.01 Tahun 1970	SOP of working at confined space	4	5	5	100	-	YES	L
			Electrocuted (if using electrical grinder)	Injury, fatality	N	Permenaker No.33 tahun 2015	Inspection	4	6	5	120	-	YES	L
			Operator's hand got hit by grinder	Cuts	N	UU No.01 Tahun 1970	Cover the grinder	5	2	4	40	-	NO	L
			Residual powder of grinder got into the operator's eyes	eye injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	6	2	3	36	-	YES	L
			Got hit by detached air hose	Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	2	4	32	-	YES	L
			Exposed to grinder's spark	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	5	2	3	30	-	YES	L
			Over air pressure (if using pneumatic grinder)	Injury	N	UU No.01 Tahun 1970	SOP of grinder usage	5	2	3	30	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
17	A. Grinder process	R	Over air pressure (if using pneumatic grinder)	Hearing loss	N	UU No.01 Tahun 1970, Per.13/Men/X/2011	Ear plug	5	2	3	30	-	YES	L
			Grinder residue scattered	the degradation of ground water quality	N	PP No 82 tahun 2001, KepmenLH No 112 tahun 2003	Area cleaning	5	2	3	30	-	NO	L
			Noise from the grinder	Hearing loss	N	UU No.01 Tahun 1970, Per.13/Men/X/2011	Ear plug	4	2	3	24	-	YES	L
			The grinder falls on the foot	Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	1	4	16	-	YES	L
			Grinder vibration	Injury, numbness	N	UU No.01 Tahun 1970	Work time management	5	1	3	15	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
17	B. Gouging process													
	a. The process of leveling material / component by beating it with a hammer	NR	Health problems due to environment noise	Hearing loss	N	UU No.01 Tahun 1970	Ear plug, ear muff	3	2	2	12	-	YES	L
			Hammer got bounced	Injury, bruise	N	UU No.01 Tahun 1970	Personal Protective Equipment	2	2	3	12	-	YES	L
	b. Destroy the current finished goods (welded workpiece) to make a new one	NR	Electrocuted	Fatality	N	UU No.01 Tahun 1970, Permenaker No. 33 Tahun 2015	Personal Protective Equipment, inspection	4	6	5	120	-	YES	L
			Exposed to the fire sparks	Burns	N	UU No.01 Tahun 1970	Personal Protective Equipment	4	4	5	80	-	YES	L
			Health problems due to environment noise	Hearing loss	N	UU No.01 Tahun 1970	Ear plug, ear muff	3	2	3	18	-	YES	L

Table 4.8 FMEA of Cement Wagon Based on ISO 45001 Policy (cont'd)

No	Process Description	Category	Potential Failure Mode	Potential Effect of Failure	Operation Condition	Applicable Regulation	Hazard Prevention	Risk Assessment				History of Accident (In 2016)	Applied ?	Risk level
								Possibilities	Severity	Detectability	Risk Priority Number (RPN)			
17	b. Destroy the current finished goods (welded workpiece) to make a new one	NR	Fires due to fire sparks on flammable materials	Property damage	E	UU No.01 Tahun 1970	SOP of Fire	3	2	3	18	-	YES	L
			Got hit by workpiece	Injury	N	UU No.01 Tahun 1970	Personal Protective Equipment	2	3	2	12	-	YES	L
			Health problems due to hot work environment	Dehydration, Fatigue.	N	UU No.01 Tahun 1970	Educate dehydration, supply gallons	2	2	3	12	-	YES	L

Notes:

R	Routine
NR	Non-routine
N	Normal
Ab	Abnormal
E	Emergency
Applied	Is hazard prevention being applied by PT.XYZ?

After the Failure Modes Effect Analysis has been made, the next step to know the company's hazard control performance is by calculating the data based on the certain formula which is:

$$HCi = \frac{Xi}{Yi} \times 100\%$$

$$HC = \frac{\sum_{t=1}^{N} HCi}{N}$$

Where:

Xi = No. of newly identified hazards in *i*-th unit, in respect to which appropriate control measures have been implemented according to schedule within a given reporting period.

Yi = Total no. of newly identified hazards in *i*-th unit, in respect to which appropriate control measures should have been implemented within a given reporting period.

N = No. of units conducting hazard identification and collecting data on newly identified hazards.

Based on the FMEA, the number of applied hazard prevention is 90 of 110 total preventive measure. So,

$$HCi = \frac{90}{110} \times 100\%$$

$$HCi = 81.81\% \; or \; 0.8181$$

$$HC = \frac{0.8181}{1}$$

$$HC = 81.81\%$$

Based on the color policy that has been elaborated in chapter 2, the PT. XYZ is currently on yellow color (70% ≤ HC ≤ 90%).

4.2.3 The relationship between gap analysis and FMEA

This section will discuss if there is a relationship between the gap analysis and FMEA. In gap analysis, there are 5 criteria that the company does not fulfil. For FMEA, there are 20 of 110 hazard prevention that the company does not apply. The relationship here means that if the company solve those 5 criteria, does it solve the problems that found in FMEA?

Table 4.9 Summary of hazard prevention that the company does not apply

No.	Hazard prevention	Quantity
1	Inspection	7
2	N-95 mask	5
3	Area cleaning	3
4	Measuring air ambient quality	1
5	Regulator	1
6	Installing safety latch	1
7	Change design	1
8	Cover the grinder	1

In table 4.9, the inspection is the biggest problem here. Then, followed by N-95 mask, area cleaning, measuring air ambient quality, regulator, safety latch, design problem, and the grinder. Each problem will be solved by linking it to the 5 criteria and other methods.

Table 4.10 Linkage between hazard prevention and 5 criteria

No.	Hazard prevention	Linkage to 5 criteria
1	Inspection	1
2	N-95 mask	-
3	Area cleaning	1
4	Measuring air ambient quality	1
5	Regulator	-
6	Installing safety latch	-
7	Change design	2
8	Cover the grinder	-

In table 4.10, only 4 problems that has linkage to 5 criteria. The prevention of each problems will be explained thoroughly later.

1. **Inspection**

Lack of inspection has a linkage to the criteria 1 in 5 criteria. For further explanation see chapter 4.2.1.

2. **N-95 mask**

PT. XYZ has its stock on the mask that needed in the manufacturing site. But, it does not fulfil the safety standard. The main reason of company does not procured the N-95 mask is because of company financial problem.

3. **Area cleaning**

Area cleaning has a linkage to the criteria 1 in 5 criteria. Operators and other employees always needs to keep the work area clean to avoid the accident.

4. **Measuring air ambient quality**

Measuring air ambient quality has a linkage to the criteria 1 in 5 criteria. For further explanation see chapter 4.2.1.

5. **Regulator**

PT. XYZ has applying a regulator to every gas station in the work area. The problem is, there is no regular check for the regulator and even there is a possibilities in finding a regulator that has been not working anymore. But, due to company financial problem, currently company does not see regulators as main threat in the workplace.

6. **Installing safety latch**

PT. XYZ currently does not have a safety latch installed in their overhead crane. But, PT. XYZ has a plan to install the safety latch in all of their overhead crane in 2017.

7. **Change the design**

Change the design has a linkage to the criteria 2 in 5 criteria. The design in here only limited to the product design. The product design needed to be changed

because changing material is out of question due to the PT. XYZ has procured mass amount of material for current design. So, by changing the current design, the force of the pressure is hopefully distributed evenly in the product.

8. Cover the grinder

PT. XYZ actually has all of the grinder covered. But, the operators keep dismantle the tools so that they can change the grinders wheel to another tool like wood saw. So, the accident that happened here is not because of the company policy but because of the unsafe act of the operators.

4.3 Summary

To summarize the research, PT. XYZ only need to do relatively small work to fulfil the clause 6 of ISO 45001:2017. The reason is PT. XYZ has already OHSAS 18001:2007 certification. Besides that, there are many of PT. XYZ policies that has similarity to the new ISO 45001:2017 but its left not recorded by the company. Currently, the company only need to maintain the current management systems and improve it in order to get the full ISO 45001:2017 certification.

FMEA (Failure Mode Effect Analysis) is a tool that used to identify the emergency scenario from each step or process of the manufacture. Risk possibilities could be reduced if the risk has been identified and the company has a counter measure for the risk. The counter measure could be anything like personal protective equipment, methods, machine, etc. FMEA is also a tool that can be used to prevent the same accident that ever occurred in the company by recording it and come up the preventive measure for the accident.

In this research, processes 11 has the highest RPN score which is 504. In the process 11 there is an accident that ever happened that caused property damage to the company. The engineering department has agreed to make that the root cause of the accident is from the design error. The bolt can't withstand the pressure that was in the product specifications. For the counter-measure for this problem, the engineering department needs to come up with a new design that has no bolt involved in order to make the pressure distributed evenly.

Although the new system has been established by the company, there are many chances that the labors will not obey the system. Many of the accident that occurred in the company is because of this reason. There are no awareness from the labors about the importance of safety of job. To increase the awareness of the operators, the company has tried to take action like training, safety talk, and make posters.

Manufacturing, quality assurance, and quality control department play a vital role to ensure the operator safety. As mentioned in the chapter 4.2.1, the inspection process of cement wagon requires more supervision or monitoring from the leader. Most of the process in the table 4.7 has low risk. The reason is because in PT. X all of the operator must undergo training process and reach some level in order to work as an operator. This program is used to minimize the possibility of accident.

For the current hazard control performance in PT. XYZ, it has 81.81% rating. This means PT. XYZ is in the yellow category. In order to achieve the company goals which is zero accident in a year, PT. XYZ need at least more than 90% of hazard control performance rating when conducting the analysis. Which means that PT. XYZ has a lot of rooms to be improved especially OH&S management systems.

After the gap analysis between PT. XYZ current management systems and ISO 45001:2017 clause 6 and FMEA has been made, researcher needs to see if there is a linkage between them. The result is, some of the problem in FMEA has a linkage to the gap analysis. The rest of the problem from the FMEA is mostly because of PT. XYZ financial problem or will be realized in 2017.

ISO 45001:2017 is only a tool to help a company to manage the systems more smoothly. ISO is not everything if the company does not implement it wholly. It still has a big chances of accident if there is a part of company that did not works to its responsibility. Even after the company has an ISO 45001:2017 certification, the company needs to maintain the management systems so that the accident rate will be decreased.

CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The conclusion of the research are as follows:

- PT. XYZ has almost fulfil all of the requirement of ISO 45001:2017 clause 6 because it already has the OHSAS 18001:2007 certification. To meet the ISO 45001:2017 requirements, PT. XYZ needs to fulfil the 5 criteria (see table 4.4, page 56).
- The highest RPN score is 504 from process 11 (Full weld and assembly man hole) (see chapter 4.3 paragraph 3) and PT. XYZ hazard control performance is 81.81% (rating is yellow) (see chapter 4.3 paragraph 6).
- By implementing the ISO 45001:2017 clause 6 to the FMEA result (in this case it would be the 8 problems that found in FMEA) the accident rate should be decreased.

5.2 Recommendation

There are some recommendations made for the problems. They are as follows:

- Instead of once a year, FMEA should be make thrice a year. If the FMEA is made for specific purposes (for each product) FMEA should be make immediately after new orders from customers taken.
- All of the operators must obedient with the rules and regulation that related to work safety for its own good. To make the operators do that it needs the cooperation from their on-site leader. Leaders need to make sure its subordinate has awareness for its own safety.
- Every supporting equipment that related to the Health, Safety, and Environment must always available for its stock. Because, the availability of the ESR department supporting equipment affect the lives of the operators.
- For future research, FMEA should be conducted with considering the type of tools that used in the manufacturing process.

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