HAZARD RISK MANAGEMENT FRAMEWORK FOCUS ON MAINTENANCE (A SYSTEMATIC LITERATURE REVIEW)

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By:

Name : Wulan Dwi Yanti

Student ID Number : 14522067

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FACULTY OF INDUSTRIAL TECHNOLOGY

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Yogyakarta, July 12 , 2021

Wulan Dwi Yanti

14522067

THESIS APPROVAL OF SUPERVISOR

HAZARD RISK MANAGEMENT FRAMEWORK FOCUS ON MAINTENANCE

(A SYSTEMATIC LITERATURE REVIEW)

THESIS

Name : Wulan Dwi Yanti

Student ID Number : 14522067

Yogyakarta, November 13, 2019

Supervisor

Prof. Dr. Ir. Raden Chairul Saleh, M. Sc.

THESIS APPROVAL OF EXAMINATION COMMITTEE

HAZARD RISK MANAGEMENT FRAMEWORK FOCUS ON MAINTENANCE (A SYSTEMATIC LITERATURE REVIEW)

THESIS

Arranged by:

Name : Wulan Dwi Yanti

Student ID Number : 14522067

Had been defended in front of Examination Committee in Partial Fulfillment of the Requirement for Degree of *Sarjana Teknik Industri* Faculty of Industrial Technology Universitas Islam Indonesia

Yogyakarta, May 27, 2021

Examination Committee

Dr. taufiq Immawan, S.T., M.M.
Examination Committee Chair

Winda Nur Cahyo, S.T., M.T., Ph.D.
Examiner I

Muhammad Ridwan Andi Purnomo, S.T., M.Sc., Ph.D.
Examiner II

Acknowledged by,
Head of Undergraduate Program
Department of Industrial Engineering
Faculty of Industrial Technology
Universitas Islam Indonesia

(Dr. Taufiq Immawan, S.T., M.M.)

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Author

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ABSTRACT

Maintenance has become an essential function and primordial necessity in industrial activity of all sector. However, although the essential nature of the maintenance operation or activities is more widely recognized, maintenance activities are identified for a long time as critical tasks for operator's safety. Three-fourths of maintenance related accidents could have been avoided if appropriate preventive measure had been put in place. Therefore, hazard risk management during maintenance is required to improve the completion probability of operations and avoid unexpected incidents. This study will review the literature systematic review focus on SLR method and hazard risk management on maintenance from the first process until finish and create the framework. Finding the framework of hazard risk management on maintenance can be helped by systematic literature review (SLR) with thematic synthesis analysis technique. SLR is a methodologically rigorous review of research result. This study used 50 papers reviewed from electronics database a several publisher and the year's publication in 2014-2021. The aims for this study is conduct systematic literature review for hazard risk management and propose maintenance framework using hazard risk management.

Keyword: *Systematic Literature Review, Hazard Risk Management, Maintenance, Electronics Database.*

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CHAPTER I

INTRODUCTION

This chapter presents the preliminary research which will be divided into six sub-chapters, which are research background, problem formulation, research objectives, research scope, research benefit, and systematics of writing.

1.1 Research Background

In this era of globalization, technological development is rapidly increasing. This situation encourages trade and industry to develop their business in Indonesia largely. Certainly, every company trying to become the leader. Therefore the business competition is getting tighter.

Manufacturing industry is defined as an economic activity that process basic goods mechanically, chemically, or manually into final or intermediate goods. It is also defined as processing of lower-value goods into higher-value goods as final or intermediate products. The activities also includes service for manufacturing and assembling (BPS-Statistics Indonesia, 2016).

Every manufacturing companies certainly have an obstacle during the production process such as the limitation of machines, humans, and environmental. Every activity in the industry or product development will definitely experience unexpected things or possibilities that cause a loss of material and set up time. The probability and magnitude of a loss, disaster, or other undesirable events is called as risk (Douglas Hubbard, 2009). Therefore, every element

and industrial activity must contribute risk that can be detrimental to the company, the company must apply risk management to minimize the effects of risk and can make mitigation planning strategies to overcome the risk. Rout and Sikdar (2017) stated that risk management is the identification, assessment, and priotization of risks followed by coordinating and organizing the resources in order to minimize, monitor, and control the probability and/or impact of unfortunate events.

Based on (ISO 31000, 2018), risk management proses describes that risk assessment and risk treatment may become the centre of risk management process. Risk management process consist of (1) defining scope, context and criteria of risk, (2) communicating and consulting, (3) monitoring and reviewing, and (4) recording and reporting. A good company must be able to handle three phases which are that is risk identification, risk assessment or risk analysis, and risk monitoring (Saedi et al., 2014). Risk identification is referred to the identification of undesired events leading to hazard materialization and the mechanism of their occurrence (Saedi et al., 2014). Risk assessment consists of a series of processes related to risk analyses, assessment of the magnitude of risk, judgment on wheter the risk is acceptable or unaccepteble and creating and assessing risk control option, to attain this goal. Risk monitoring or control measure is determine with respect to the source of the hazard the application of engineering controls, administrative controls, and personal protective equipment (Saedi et al., 2014).

Risk assessment consists of three steps, which are risk identification, risk analysis/risk measurement, and risk evaluation. After establishing the content, the next step is to identify potential risks. Risk is about events that when triggered will cause problem. Therefore risk identification can start with the source of problem or with the problem itself (Rout, Sikdar, Surgeon, & Bengal, 2018). Once risk has been identified, it must then be assessed as to its

potential severity of loss and to the probability of occurrence. Therefore, in the assessment process, it is critical to make the most possible estimation in order to prioritize the implementation of risk management plan. The basic difficulty in risk assessment is determined by the rate of occurrence since the statistical information is not available on all types of past incident (Chernukha, Kuznetsova, & Sysoy, 2015). After risk measurement, the next step is risk evaluation which refers to determine whether the risk exceeds the organizational risk tolerance or not, and to sort the risk priorities for the treatment plan. Risk priorities is not always fixed, new risk can be arise and risk priorities can change. In determining the risk priority which is the main basis for the organizational goals, it is contained in the business plan. The outputs from risk evaluation are risk map and list of risk priority (Rout et al., 2018).

A risk company must make a plan or strategy to optimize the system work in industry and to overcome any possible risk. One of the most important strategies is maintenance plan conducted by the maintenance division to minimize the impact of hazard risk. Data that has been obtained by researchers from electronics database there are 38 papers related to hazard risk management. Therefore the researcher will conduct systematic literature review to identify current and future studies. After that review those literatures in detail according to the topic which will create hazard risk management framework focus on maintenance is chosen as on of important business process in company. The problem occurs when there are more aspects which affect the hazard risk management framework that focused on maintenance which will be discussed using systematic literature review.

1.2 Problem Formulation

Based on the description of the background above, the researcher formulates several things that need to be studied and discussed in more depth. The formulation of the problem to be discussed is as follows:

1. What are the aspects that will affect maintenance focused hazard risk management?
2. What improvement can be apply in hazard risk management framework to address aspects affecting hazard risk management in maintenance?

1.3 Objective Research

Based on problem formulation described above, the objective of this research is to find out what aspects will affect hazard risk management framework focus in maintenance and improving hazard risk management within maintenance framework. Things that will be done are:

1. Implement the systematic literature review (SLR) method to compile an electronic database or relevant publication that will help identify the aspects that affect the hazard risk management focus on maintenance

2. Improved the hazard risk management framework on maintenance for the development of maintenance in the industrial 4.0 era.

1.4 Research Scope

Research scope is the scope of the study, this needs to be done so that research to become more focused. The scope of this research are:

1. The research is focused on hazard risk management which starst from identification hazard risk.

2. The research conducts a systematic literature review. Finding and discussion are derived from the relevant publications.

3. The relevant publication were collected from several electronic database, such as Elsevier, Wiley, IEEE, Emerald Insight, and JSTOR.

4. The time of publication is limited from 2014 - 2021

5. 50 papers were used to support the literature review

1.5 Research Benefits

Based on the formulation of the problem and the research objectives, hopes that this research can provide the following benefits:

1. Adding scientific insights about hazard risk management, especially on maintenance division

2. Research methodology can be used to conduct systematic literature review

3. Further research recommendation can be used for better future research

1.6 Systematics of Writing

The reseach reports is divided into six chapters. The six chapters are following:

CHAPTER I INTRODUCTION

In this chapter the introduction of the reseacrh will be explained into six sub chapters, which are the background that underlies the problem, the problem formulation, the research objectives, the research benefit, and systematics of writing.

CHAPTER II LITERATURE REVIEW

This chapter explains about the review of inductive and deductive literature which contains theories related to research, along with previous researchs which are the basis for determining research mehods.

CHAPTER III RESEARCH METHODOLOGY

This chapter explains the research methodology outlined into 4 sub chapters which are the focus and object of research, data collection, processing and analysis methods, and summary & suggestion..

CHAPTER IV SYNTHESIS AND ANALYSIS

This chapter presents information of data that have been collected during the research. It also contains problem solving using the proposed model or tools that are implemented in the data processing as well the analysis using the proposed model. This chapter also explain more the synthesis and analysis in phase of systematic literature review, it contains how the selection method for synthesis and analysis, and how the extraction data of paper.

CHAPTER V DISCUSSION AND RESULT

This chapter provides a discussion after data analysis. Furthermore, it also discusses about the result of framework of hazard risk management focusing on maintenance, in order to overcome the problem.

CHAPTER VI CONCLUSION AND RECOMMENDATIONS

This chapter explains conclusion and recommendation. This chapter contains conclusions on the analysis and recommendations or suggestions for the results which are found during the research. The recommendations need can be used as an insight as future research perspective.

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ATTACHMENT

CHAPTER II

LITERATURE REVIEW

This chapter explains the inductive and deductive review. An inductive review is a study obtained from facts or results from previous studies that have been published both or not, which related to this research. While deductive review is review obtained from books related to this study (Saputra, 2016). In this review the inductive reviewed includes all publications for the past seven years (2014 – 2021). This review is arranged using systematic literature review (SLR) method. This method can identify, assess, and interpret all findings on a particular research topic (Fink, 2014). Furthermore, the CK-Chart planning and tools are used as tools for measuring systematic research in the form of tree diagrams. The reviewed publications were derived from the reliable publisher such as Elsevier (75.0%), Willey (1.78%), Emerald Insight (3.57%), IEEE (3.57%), JSTOR (5.35%), and Google Scholar (10.71%). Table 2.1 shows the percentage of inductive and deductive review.

Table 2. 1 Percentage of Inductive and Deductive Review

No	Resources	Total	Percentages
1	Books	6	10.71%
2	Science Direct	42	75.0%
3	Emerald Insight	2	3.57%
4	Wiley	1	1.78%
5	IEEE	2	3.57%
6	JSTOR	3	5.35%
Total		**56**	**100%**

2.1 Inductive Review

2.1.1 Hazard Risk Management

Risk management is the identification,assessment, and prioritization of risks followed by coordinated and economical application of reseources to minimize, monitor, and control the probability and or impact of unfortunate events (Douglas Hubbard,2009). Risk managment generally applies to a management process in an organization to maximize the realization of opportunities.

The earliest risk management record was from Bavylon in the Code of Hammurabi, dating from around 2100 BC. This concerns ‘bottomyry’, a form of naval insurance whereby the owner of the vessel can borrow money to buy cargo and does not have to pay the debt if the ship is lost at sea. The term ‘bottomry’ refers to pledging the bottom of your boat to the lender (Kid Sadgrove,2005).

Untill recently, insurance was still the main way that companies managed risk. Thus in the 1960s and 1970s, insurance companies sought to reduce their potential losses by encouraging businesses to make their premises safer. This was the first age of risk management. Businesses considered only non-entrepreneurial risk (such as security). They also used risk reactively, to see how much insurance they should buy (Kid Sadgrove, 2005).

The seconds age of risk management, in 1970s and 1980s, businesses started to introduce quality assurance, to ensure that products conformed to their specifications. This was heralded by the British Standards Institution (BSI) launching the quality standard BS 5750 in

1979 (it self the successor to US military Standard MIL-Q-9858 launched in 1959). Companies treated risk in a more proactive or preventative way (Kid Sadgrove, 2005).

The third age of risk management arrived in 1995 with the publishing by Standards Australia of the world's risk managemnet standard, AS/NZS 4360:1995, which has now been updated three times. This was followed by the Canadian standard CAN/CS-Q850-97. After know about the history of risk management will explain the previous research of risk managem.

Anita Meidell and Katarina Kaarboe (2017) conducted a research on how the enterprise risk management (ERM) function influences decision making in the organization at Global Oil and Gas Company. The pourpose of this research is to examine the transformation of the ERM (Enterprise Risk Mangement) function's influence in a company over time. This research conducted 35 interviews with 30 different individuals. The interviewes were enterprise risk managers trying to gain influence, safety risk coordinators in the business areas and managers using the risk technologies from the ERM function. After they finished the test they get result, the first is ERM Function gradually accumulates more influence over three phases as new risk management technologies are introduced. However, the nature of the increased influence is not the same from one time periode to another. The second result is the introduction of new technologies is not sufficient to increase influence. The ERM function in case company has to sell two ideas of managing new ideas and manging knowledge across boundaries to influence decision making in the organization.

Furthermore Fabio Lotti Oliva (2016) conducted a research on amaturity model for enterprise risk management in the supply chain of Brazilian companies. This research purpose is to analyze the enterprise risk management in the supply chain of Brazilian companies. The research consisted of several survey with experts who validated the expectations, assumptions,

and options on the overall purpose of the analysis of enterprise risk managemnet in the supply chain of Brazilian companies. After that, the survey development with managers from large companies is to indentify what the main risks are assessed on their supply chain and what the main characteristics are in the risk management of these companies. The third consisted of the development of a proposal to systematize the process of enterprise risk analysis in the supply chain in which the company participates. The result of this reseacrh is the companies in the intermediate level of maturity have an enterprise risk management with a high degree of organization, and greater decentralization, that is, distinctive characteristics in the past literature, today they are common to the companies.

Moreover, Wijeratne et al. (2014) identified and assessed risk in maintenance operations. This research purpose is to identify occupational risks in maintenance work and the risk assessment methods in place and their drawbacks in the Sri Lankan context. This research using the software program Nvivo (Nvivo version 8.0.340.0 SP4) produce by QSR (Qualitative Solutions and Research Ltd) for coding function to simplify the works relating to content analysis. The result in this research is risk assessment cannot be effectively carried out. The need for a considerable amount staff time and resources cause the risk assessment to be carried out hurriedly which can provide ineffective results. Lack of standards to assess the probability of occurrence and difficulty in evaluating the severity of a risk event make the process and techniques involved in risk assessment subjective, thus, making it a subjective process. As the level of exposure cannot be assessed accurately, the risk level identified may not be correct.

Mustafa and Al-mahadin (2018) investigated the risk assessment of hazards due to the installation and maintenance of onshore wind turbines. The objectives of this research is to contribute in the proper risk asseesment of potential hazards, which enhances the ability to devise passive and active protection measures to reduce the effects of a catastrophic event. This

research used risk assessment method which consists of hazard identification, risk analysis,risk evaluation and risk control. The risk is high and may affect people passing by these parts while being transported. Wind turbine workers are susceptible to many types hazards, when installing and maintaining wind turbines, like slipping, tripping, and falling. The conclusion of this research is wind turbine transport, installation, maintenance and operation may cause different types of hazards which should be analyzed and managed in order to reduce the likelihood and severity of incidents and accidents. The systematic process of risk assessment provides a clear understanding of the potential hazards and their causes. It makes easier to identify possible hazards, analyze and evaluation the risk and eventually lay out the proper measures to control these risks.

Gonzalez et. al (2015) identified the hazard effectiveness model on construction worked and maintenance industry. This research purpose is to improve the hazard identification effectiveness of the worker. The method used in this research is in identify a hazard, the worker is first required to perform a visual search within his/her surroundings. This shall entail searching for unique visual stimuli among the entire search space. These visual stimuli are the actual occupational hazards in a machine room, for example according to the theory of visual attention, during a visual search, the detection of these visual stimuli is influenced by the strength of the stimuli itself. The conclusion from this research is a simple mathematical model that could be used in describing the effectiveness of a worker in identifying safety hazards in the construction and maintenance industry is presented. The model is based on simple probability principles which could easily be measured by testing the worker for different hazards. It was also shown since there are many hazards in pratice, it is necessary to have a hazard effectiveness map which can easily show the strengths and deficiencies of a worker in

therms of hazard identification. Finally, continuous practice and education/training of workers are highly recommended in improving their hazard identification effectiveness.

Saedi et. al (2014) conducted a research on hirarc model for safety and risk evaluation at a hydroelectric power generation plant. This research purpose is to create a hirarc model for the evaluation of environmental safety and health at a hydroelectric power generation plant at cameron highlands in Pahang, Malaysia. The used methodology in this research is a hirarc model or hazard identifictaion, risk assesement, and risk control. The result from this research is the data collected from the study power generation plant was based on survey, interview, hazard checklist, accident and job hazard analysis. Total 41 important hazards were identified in the operation which were assessed by a checklist analysis technique. The 41 important hazards were classified into three level with three degrees of risks followed by the methodology of risk assessment.

Heidari et. al (2016) conducted a research on risk assessment in Iranian drilling industry. This research proposed several strategies to reduce accidents and losses in drilling industry by comprehensive HSE risk assessment. The research aim is to identify the solution to reduce incidents in the drilling industry to support the national strategy development.. The used methodology in this research is risk assessment and hazard identification. In this research, for the purpose of this study the recognized related standards and guidelines were identified and scrutinized. The conclusion of this research identified different types of risks in drilling industry and among all identified risks the most important risks (66 risks) were determined by expert judgement. The result showed that the lack of management was the most important factor affecting the accidents in Iranian drilling industry.

2.1.2 Risk Assessment Framework

Risk management process describes risk assessment and risk treatment that become the center of risk management process. Risk management process consists of (1) scope, context and crieteria of risk, (2) communication and consultation, (3) monitoring and review and (4) recording and reporting (ISO 31000, 2018). Figure 2.1 illustrates risk management process that find the risk level and determine the strategy to avoid the risk. In this risk management process have five steps but in this paper we can focus in 4 step that is Identification of Risk, Risk Assessment, Risk Treatment and Response, and Monitoring & Control (ISO 31000, 2018).

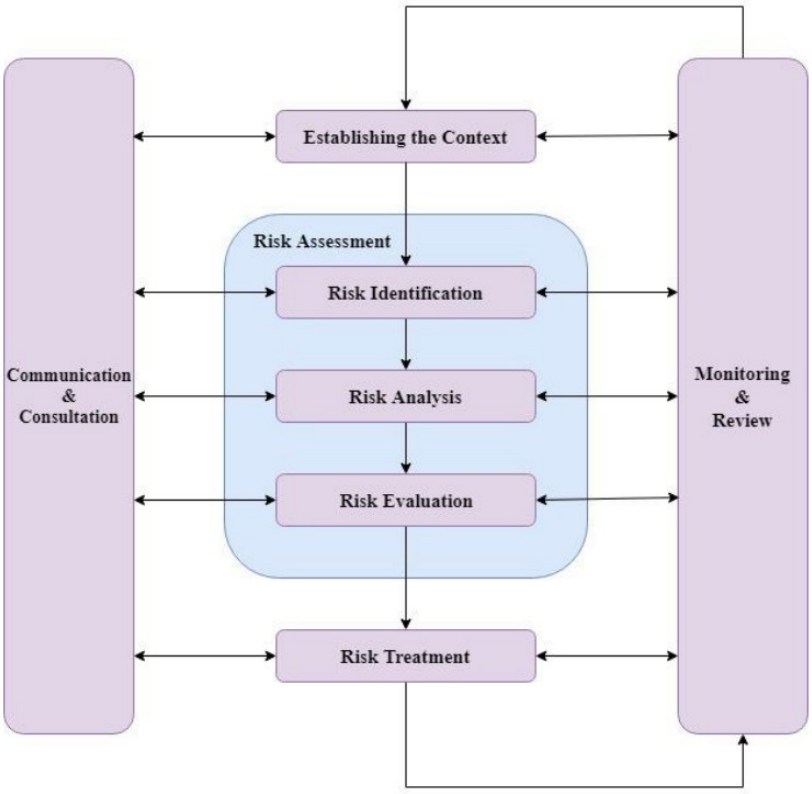

Figure 2. 1 Risk Assessment Framework

- Establish the Context

Establishing the context includes planning the remainder of the process and mapping out the scope of the exercise, the indentity and objectives of stakeholders, the basis upon which risks will be evaluated and defining a frameworkfor the process and agenda for identification and analysis (Rout et al., 2018)

- Risk Assessments

Risk asessment consists of a series of processes related to risk analyses, asessment of the magnitude of risk, judgement on whether the risk is acceptable or unacceptable, creating, and assessing risk control options toattain this goal. Risk asessment plays an important role in the decisions made by an organization in order implement safety and health policies in a rational manner (Saedi, Thambirajah, & Pariatamby, 2014).

- ✓ Risk Identification

After establishing the content, the next step is to identify potential riks. Risk are about events that, when triggered, will cause problem. Therefore, risk identification can start with the source of problems, or with the problem itself (Rout et al., 2018).

Risk identification requires knowledge of the organization, the market in which it operates, the legal, social, economic, political, andclimatic environment in which it does its business, its financial strengths and weaknesses, its vulnerability to unplanned losses, the manufacturing process, the managemnet system and business mechanism

by which it operates. The identification method are formed by templates or the development of templates for identifying sorce, problem or evet (ISO 31000, 2018).

Risk Identification is referred to the identifying of undesired events leading to hazard materialization and the mechanism of their occurrence. Risk assessment consists of a series of processes related to risk analyses, assessment of the magnitude of risk, judgment on wheter the risk is acceptable or unaccepteble and creating and assessing risk control option, to attain this goal. In risk monitoring or control measure were determine with respect to the source of the hazard the application of engineering controls, administrative controls, and personal protective equipment (Saedi et al., 2014).

- ✓ Risk Analysis/Risk Measurement

Once risk have been identified, they must then be assessed as to their potential severity of loss and to the probability of occurence. These quantities can be either simple to measure in the case of the value of a lost building or impossible to know for sure in the case of the probability of an unlikely event occurring. Therefore in the assessment process, it is critical to make the best-educated guesses possible in order to properly prioritize the implementation of the risk management plan. The fundamental difficulty in risk assessment is determining the rate of occurrence since statistical information is not available on all kinds of past incidents (Chernukha et al., 2015).

Assessment of risk or potential risk events id carried out to determine the level of risk with implemented 2 perspectives (LSPMR, 2018), namely:

- Impact/Consequences

Impact or consequences of events is the level of loss and/or potential loss or damage that occurs from an event based on historical experience and/or possibility in the future. Impact tables are made as guidelines to determine the impact criteria of each event (e.g. Financial, Operational, Human Resource Management, Reputation, etc.). Determine of impact table at the first time should be done by Senior Manager. Table 2.2 will be illustrating the impact table in order to determine score and rating of event.

Table 2. 2 Impact Score and Ration for Events

Impact of Occurrence	Score	Description				
		Impact on Service Objectives	Financial Impact	Impact on People	Impact on Time	Impact on Reputation
Catastrophic	5	Unable to function inability to fulfill obligations	Severe financial loss	Death	Serious: In excess of two years to recover pre event position	Highly damaging, severe loss of public confidence
Major	4	Significant impact on service provision	Major financial loss	Extensive injury, major permanent harm	Major: Between 1 – 2 years to recover to pre event position	Major adverse publicity, major loss of confidence

Moderate	3	Service objectives partially achievable	Significant financial	Medical treatment required, semi-permanent harm up to 1 year	Considerable: Between six months to 1 year to recover to pre event position	Some adverse publicity, legal implications
Minor	2	Minor impact on service objectives	Moderate financial	First aid treatment, non-permanent harm up to 1 month	Some:2 to 6 month to recover	Some public embarrassment, no damage to reputation
None	1	Minimal impact, no service disruption	Minimal loss	No obvious harm/injury	Minimal: up to 2 months to recover	No interest to the press, internal only

- Likelihood/Frequency

Likelihood or frequency of events is the level of probability of a risk occouring is often compared to all activities and/or periods of time based on historical experiences and/or possible in the future. Likelihood tables are created as guidelines to determine the possible criteria for each events. Determination of the table possible for the first time should be done by the Senior Manager (LSPMR, 2018).

To facilitate in determining the likelihood level/ value, the risk owner (someone who is responsible for monitoring risks and responding to those risks) can just sort out a risk or events based on the nature.

- Routine : daily transaction errors, daily/weekly input data.
- Non routine: stop production, customers complain, lawsuits
- Possible events in the future: regulation changes, fire, natural earthquake

Table 2. 3 Likelihood Score and Rating for Events

RATING	*DESCRIPTION*	*PROBABILITY OF RISK OCCURANCE*	*NON ROUTINE*
Rare (1)	Almost never happen, very unlikely this will ever happen	< 20%	Maximum occour once a month
Unlikely (2)	Not expected to happen but is possible	20% - < 50%	Maximum accour five times a month
Moderate (3)	May happen occasionally	50% - < 70%	Maximum occur 10 times a month
Likely (4)	Will probably happen, but not a persistent issue	70% - < 90%	Maximum occur 15 times a month
Almost Certain (5)	Will undoubtedly happen, possibly frequently	> 90% - < 100%	Occour morethan 12 times a month

Table 2. 4 Risk Rating

Risk Atribute		Risk Score	
		Start	**Maximum**
SR	Insignifant No effect on the company Action : Monitoring	0	1
R	Minor Does not interfere with the process Action : Manage by routine produce	1	4
S	Moderate Emerging costs or business process temporarily interrupted	5	9

	Action : Management responsibilities must be specfied		
T	Major Stop temporarily business process Action : Senior management attention required	10	15
ST	Extreme Company goes bankrupt or liquidated Action : Immediate action required	16	25

✓ Risk Evaluation

Risk Evaluation refers to determining whether the risk exceeds the organizational risk tolerance or not, and sorting the risk priorities for the treatment plan. Risk priorities are not always fixed, new risk can arise and risk priorities can change. In determining the risk priority which is the main basis for the organizational goals, it is contained in the business plan. The output from risk evaluation is a risk map and list of risk priorities (Rout et al., 2018).

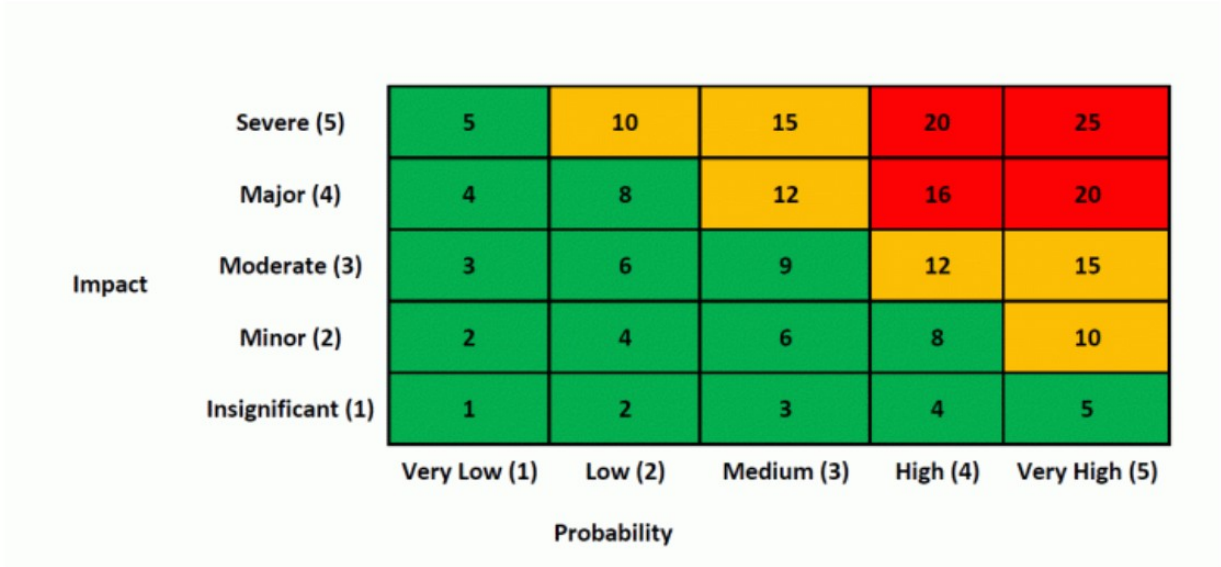

Figure 2. 2 The Risk Maps Diagram

Risk map is risk graphical representation of risk events on the basis of Impact and Likelihood levels in a particular business entity. Used to indicate risk position and prioritize risk response. Risk maps can be made in the from of inherent risk maps and/or residual risk maps, tailored to the needs of each organization (LSPMR, 2018).

- Risk Treatment and Response

Once risks have been identified and assessed next step is risk treatment. Action was taken by management to reduce the risk (impact and/or likelihood) to the acceptable level of residuals, according to the company's risk appetite or risk tolerance. in dealing with risk there are 4 categories of treatment strategies addressing risk:

- ✓ Accept: accept the level of risk that occurs (still within the limits of appetite and risk tolerance) and maintain / manage so as not to develop at a high level.
- ✓ Share: share the risks faced by other parties (handling with insurance, guaranteeing credit, outsourcing, partnership, leasing, hedging, etc).
- ✓ Reduce: reduce the possibility and / or the impact of a risk (for example: improving procedures, making new policies, replacing / buying tools, diversifying products, training, etc).
- ✓ Avoid: avoiding risk by not carrying out activities or stopping activities that increase risk (example: selling a business unit, not expanding to a new geographic market). Avoiding risks before they occur need analysis based on historical data, or expert opinion. in choosing avoid option must consider the impact on the organization's objectives / targets and the possibility of missing opportunities (losing the possibility of benefits if the expected value is greater than the potential loss).

- Monitoring and Control

  In monitoring step, the company will be doing monitoring activities such as:

  - ✓ Routine monitoring of the actual performance the application of risk management to the original plan
  - ✓ Ensure that risk control/mitigation is effective
  - ✓ Identifying new risks that arise
  - ✓ Focusing on high and critical risks, monitoring the realization action plans are carried out more often than low risks.
  - ✓ To low risks must be monitored to fixed there are still in low risks categories and not changes or not increase.
  - ✓ Deviations from each step in the risk management process.

2.1.3 CK-Chart

Based on the literature review that has been done, it can be made a CK-chart research. CK-chart planning and tools is a tool to organize systematic research in the form of tree diagram. The CK-chart consists of five layers, the general title contains the problem to be resolved. Scope of issues contains the scope of the issues related to the problem. Methodology contains specific methods that will be used to solve problem. The results contain parameters that will be used in the methodology that has been determined. While the timeline contains the limitations and rules of the problem to be examined. The following the CK-chart of the research to be.conducted.

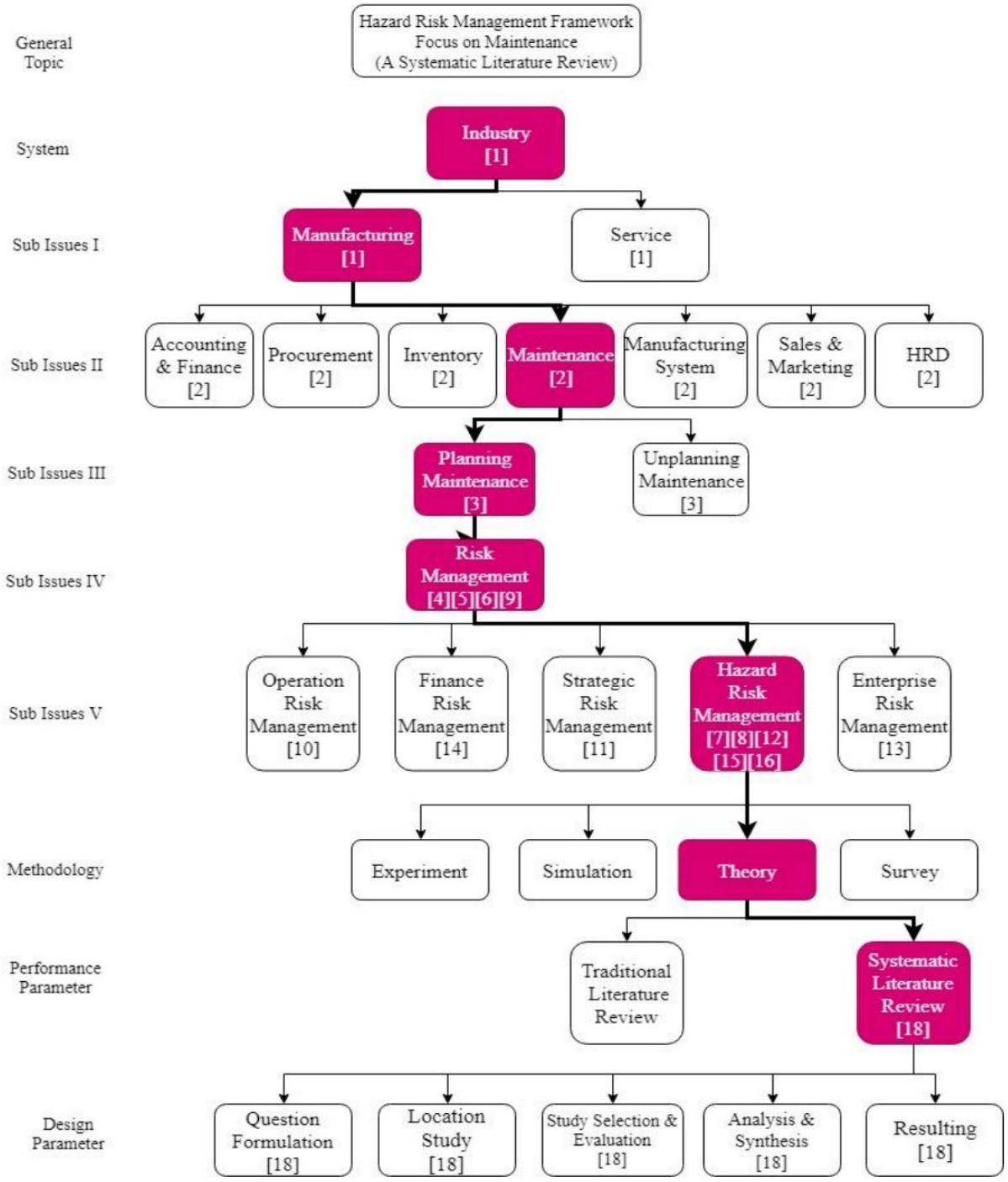

Figure 2. 3 CK-Chart Planning and Tools

Based on Figure 2.3 CK-chart planning and tools above the general topic are hazard risk management framework focus on maintenance (a systematic literature review) to implementing hazard risk management framework in maintenance by conduct systematic literature review. The system on the CK-Chart above shows the scope that focuses on the

problem to be resolved. In Industry system divided into 2 on of is maintenance which information obtained based on sources get from papers and journals that have been studied. From maintenance divided into 2 is planning maintenance un-planning maintenance. Then next subsystem is risk management include in planning maintenance. This research focus in hazard risk management. The methodology used an theory with performance parameter is systematic literature review. All elements that are focused on the CK-Chart have a basis that comes from paper and textbooks. The elements contained in the CK-Chart will be explained in sub-chapter 2.2 deductive review.

2.2 Deductive Review

In this sub chapter will be explain about the elements contained in the CK-Chart.

2.2.1 Industry

According to UU No. 5 1984, Industry is Economic activity that processes raw materials, semi-finished goods, and / or finished goods with a higher value to the user including design and engineering activities of the industry. Industry is defined as a production unit engaged in economic activity, producing goods or service, located in a building or in a certain location, keeping a business record concerning the production and cost structure and having a person or more are responsible to those activities(BPS-Statistics Indonesia, 2016).

From the various definitions of the above it can be concluded that the industry is an economic activity that is carried out by a person or group of people. In process resources into something that has more value and can be beneficial to humans. In addition the industry must have one place to operate industrial activities. The central office of statistics RI that the industry

produces goods or services. This can mean that the industry can be divided into 2 is the goods / manufacturing industry and the service industry.

2.2.2 Manufacture Industry

Manufacturing industry is defined as economic activities processing basic goods mechanically, chemically or manually into final or intermediate goods. It is also defined as processing of lower value goods into higher value goods as final or intermediate products. The activities also include servies for manufacturing and assembling (BPS-Statistics Indonesia, 2016). The manufacturing industry taked various raw materials and turns them into manufacture goods. Then used further in production or a final product for consumers. This transformation is carried out with machines driven by human power. As a result, utilizing energy sources and materials for processing (Parker W.H., 1972: 158).

From the above definitions it can be concluded that the manufacturing industry is economic activities carried out by humans to transform raw materials into finished goods. In the module Enterprise Resource Planning (ERP) is mentioned several parts of the business process in a company that is (1) Procurement, (2) Inventory, (3) Production Systems, (4) Sales and Marketing, (5) Plant Maintenance, (6) Accounting & Finance, and (7) Human Resource Planning.

2.2.3 Maintenance

Maintenance system definition is an activity to treat or maintain facilities / equipment manufacturers and made repairs or adjustments and replacements required so there is a satisfactory state of production in accordance with what was planned (Assauri, 2008). By

Patrick (2001), maintenance is an activity to preserve and maintain the facilities as well as repair, adjustment or replacement is required to obtain an operating condition perencanaanyang production to fit there.

From this definition it can be concluded that maintenance is a series of activities needed to maintain a product or system that remains in a safe, economical, efficient and optimal operation.

In industry 4.0 era maintenance, some upgrade process and industry 4.0 era maintenance become to maintenance 4.0 or maintenance in industry 4.0 era. Maintenance 4.0 is the application of machine learning, automated processes, and robotics or drones to reliability and maintenance activities. The image depicts each stage of the repair process in the scenario when unscheduled downtime is replaced by scheduled downtime. Maintenance 4.0 includes a holistic views of source of data, ways to connect, ways to collect, ways to analyze and recommended actions to take in order to ensure asset function (reliability) and value (asset management) are digitally assisted (Bona, Cesarotti, Arcese, & Gallo, 2021).

For example, traditional maintenance 1.0 includes sending highly trained specialist to collect machinery vibration analysis readings on pumps, motors, and gearboxes. Maintenance 4.0 includes a wireless vibration sensor connected to could server and machine learning platform to analyze the complex patterns and provide automated service advice to the asset owner. With maintenance 4.0 thee vibration specialist will no longer waste time going to the data. The data, when in need of subject matter expert analysis, will go to the human. The decisions are what we call “digitally assisted” (a partnership between human and machine).

According Bona et,al., (2021), Maintenance 4.0 is about putting smarter technology to work to enhance everyday factory operations. Some of the cornerstones of maintenance 4.0 include preventive and predictive maintenance, condition monitoring and trigger based maintenance, life cycle engineering, leaner manufacturing maintenance, and automation of clerical maintenance tasks.

2.2.4 Planning Maintenance

Accoring Corder (2000), Planned maintenance is maintenance that is carried out in an organized manner to anticipate equipment damage in the future, controlling and triggering in accordance with a predetermined plan. Planned maintenance is carried out in a planned maintenance to anticipate failed equipment in the future. From this definitions it can be concluded that planning maintenance is carried out in an organization a already planning.

Predictive maintenance (PdM) is maintenance that monitors the performance and condition of equipment during normal operation to reduce the likelihood of failure. The goal of predictive maintenance is the ability to first predict when equipment failure could occur (based on certain factors), followed by preventing the failure through regularly scheduled and corrective maintenance (Sarmiento et.al., 2020).

According Ruiz et. al., 2020, in the research predictive maintenance can’t exist without condition monitoring, which is defined as the continuous monitoring of machines during process conditions to ensure the optimal use of machines. There are three facets of condition monitoring: online, periodic, and remote. Online condition monitoring is defined as the continuous monitoring of machines or production processes with data collected on critical speeds and changing spindle positions or condition monitoring of rotating machines. Periodic

condition monitoring which is achieved through vibration analysis, gives insight into changing vibration behavior of installations with a trend analysis or condition monitoring of rotating machines. The last, remote condition monitoring, as its name suggests allows equipment to be monitored from a remote location with data transmitted for analysis.

Remote condition monitoring have one software a use that called CMMs or computerized maintenance management system. The definition of CMMs is a software package that maintains a computer database of information about an organization maintenance operations. It helps optimize the utilization and availability of physical equipment like vehicles, machinery, communications, plant infrastructures, and other assets. Also referred to as CMMIS or computerized maintenance management information system (Mirka & Jaime, 2020).

CMMs are found in manufacturing, oil & gas production, power generation, construction, transportation, and industries where physical infrastructure is critical. The core of a CMMs is its database. It has a data model that organizes information about the assets a maintenance organization is charged with maintaining as well as the equipment, materials, and other resources to do so (Chen et. al., 2019).

2.2.5 Risk Management

Darmawi (2014), risk management is an attempt to identify, analyze and control the risks in every activity of the company in order to obtain effectiveness and higher efficiency. Risk Management is The identification,assessment, and prioritization of risks folowwed by coordinated and economical application of reseources to minimize, monitor, and control the probability and or impact of unfortunate events(Hubbard, 2009). Risk Managment generally

applied to a management process in an organization to maximize the realization of opportunities.

Risks can come from various sources including uncertainty in financial markets, threats from project failures (at any phase in design, development, production, or sustainment life-cycles), legal liabilities, credit risk, accidents, natural causes and disasters, deliberate attack from an adversary, or events of uncertain or unpredictable root-cause. There are two types of events i.e. negative events can be classified as risks while positive events are classified as opportunities. Several risk management standards have been developed including the Project Management Institute, the National Institute of Standards and Technology, actuarial societies, and ISO standards. Methods, definitions and goals vary widely according to whether the risk management method is in the context of project management, security, engineering, industrial processes, financial portfolios, actuarial assessments, or public health and safety (Botezatu, 2016).

Strategies to manage threats (uncertainties with negative consequences) typically include avoiding the threat, reducing the negative effect or probability of the threat, transferring all or part of the threat to another party, and even retaining some or all of the potential or actual consequences of a particular threat, and the opposites for opportunities (uncertain future states with benefits) (Lincoln, 2009).

2.2.6 Hazard Risk Management

Before explain about the definition of hazard risk management the better we discuss one by one the definition of hazard risk management. First hazard is events or physical conditions that have the potential to cause fatalities, injuries, property damage, infrastructure damage,

agricultural loss, damage to the environment, and interruption of business or other types of harm or loss (Rout et al., 2018). Next is the definition of risk, risk is the product of probability (likelihood) and consequences of an event. Then management is to take charge or care of control (Hubbard, 2009).

Hazard risk management is a continual process that provides a general philosophy and a defined and iterative series of component parts that be utilized to exercise a level of control or management over the risks associated with the hazards facing a community (Rout et al., 2018).

2.2.7 Systematic Literature Review (SLR)

Systematic literature review (SLR) is one of method that adapts a precise, transparent and explicit approach that includes a series of phases to ensure that an appropriate rigor and transparency is brought to the literature review process (Fink, 2014). According to Garza-reyes (2015), there are five phases of SLR which will be explained briefly in this sub-chapter. First phase is question formulation which will formulate research questions that will guide the research. Second phase is locating studies are found by using electronic database. Then third phase is study selection and evaluation, which will select and evaluate relevant literature. Fourth phase is synthesis and analysis which will synthesize and analyze selected articles, then final phase is reporting and using the result to report the findings.

2.3 Conceptual Model

Focus on the topic already mentioned in CK-Chart above, the method and tools should be determined and prepare to review the literature systematically. Implementing the conceptual

model of conduct systematic review, so there are five phase that must be prepared (Fink, 2014). Figure 2.4 shows the step and tools that needed to conduct systematic literature based on the reference.

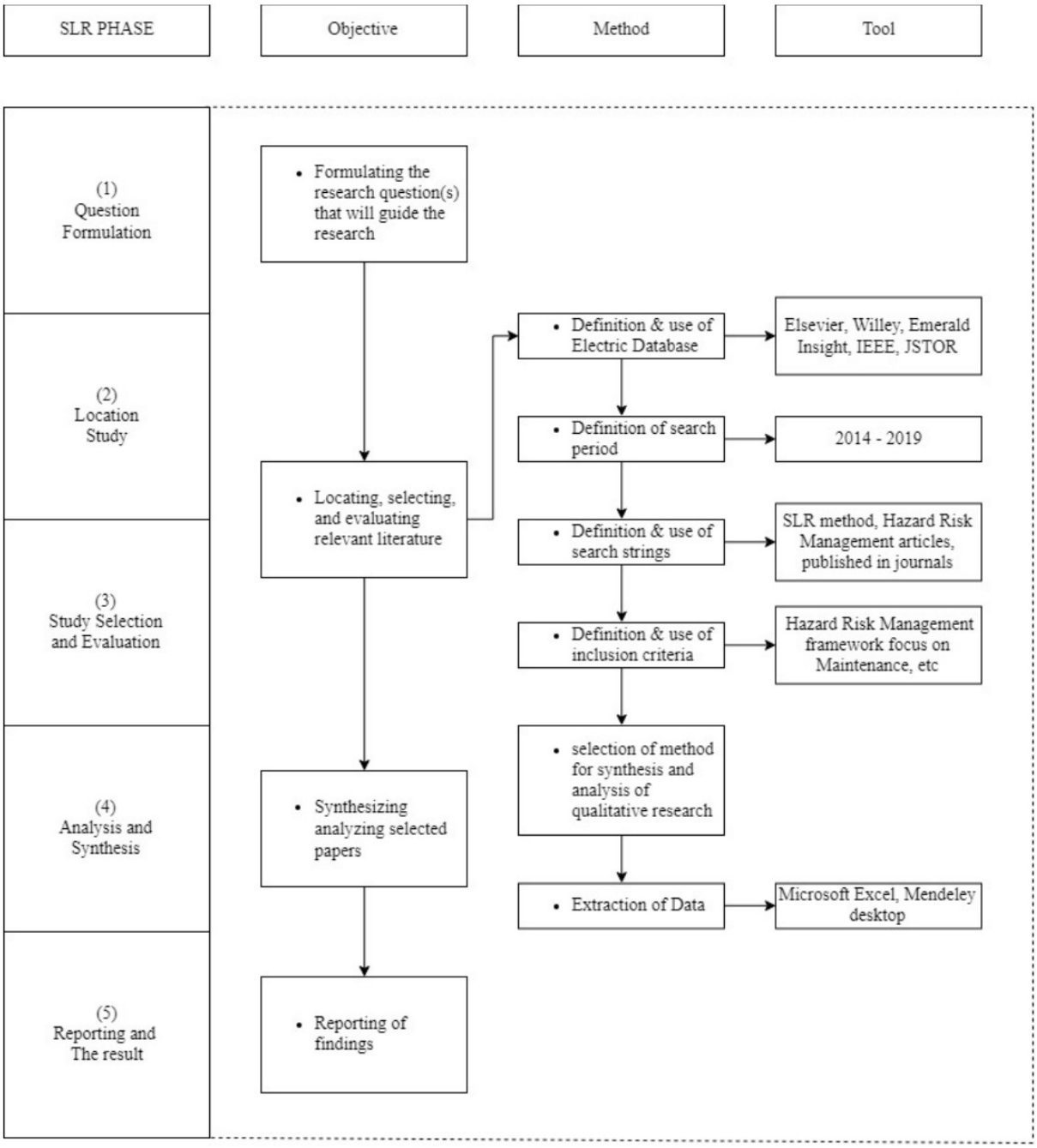

Figure 2. 4 Steps, Method, and Tools of Systematic Literature Review

Figure 2.4 above shows that there are five steps of systematic literature review and there are three points as the step stone to get the result, those are objective, method and tools. Objective is the specific explain of what to do in the phase and then method is the further information of how is the phase is doing and the last is tools to complete the method. Further information of each steps will be explaining below:

1) Question Formulation

   Formulated research question that will guide the research about hazard risk management framework in maintenance.

2) Locating study

   This phase chosen the electronic database which are Elsevier, Willey, Emerald Insight, IEEE and JSTOR to find the papers and its search period which start from 2014 – 2019.

3) Study selection and Evaluation

   This phase defined inclusion criteria and search strings. Search strings include (Risk Management), (Hazard Risk Management), (Hazard Risk Management in Maintenance), (Risk Management Process), and (Risk Assessment). They will be on article published in academic journals and proceedings of international conference with reference to hazard risk management.

4) Synthesis and Analysis

   This phase synthesize and analyze the selected papers. The papers will be synthesized into macro processes of hazard risk management, publication journal, and publication year. It will also analyze whole process of hazard risk management in maintenance.

5) Reporting and using the report for further research

   This phase will report the result of analysis and use it for further research.

2.4 Conclusion

Based on literature review, there have been differences from previous studies. What is the difference between this research and the research that has been done before is that this study will apply the SLR (systematic Literature Review) method to conduct on papers or journals for hazard risk management framework in maintenance.

CHAPTER III

RESEARCH METHODOLOGY

This chapter explained the research methodology outlined into 4 sub chapters which are focus and location of research, study selection and evaluation, tools analysis, and flow of research.

3.1 Focus and Location of Research

The place of research is the subject, person or object observed in the study as a target. While the focus of the research is the object that is the subject matter to then be observed and examined.

3.1.1 Focus Research

Focus research is conduct the SLR (Systematic Literature Review) method in hazard risk management framework in maintenance papers.

3.1.2 Locating of Research

The location of studies are found by using electronic database which are Elsevier (sciencedirect.com), Willey (willey.com), Emerald Insight (emeraldinsight.com), IEEE (ieee.org), and JSTOR (jstor.org). Research about hazard risk management framework focus on maintenance are searched in 7 years period papers which are from 2014 – 2021. According to the objective of this research, the references paper that reviewed focus on paper of hazard risk management. The keyword which present the hazard risk management used in the search

of electronic database, include risk management process, hazard risk management, and ISO of risk management.

3.2 Collecting and Processing Data

3.2.1 Collecting Data

In conducting a study, data is something that is important so that the research conducted can be recognized as true. In research the type of data will be divided into two, namely:

1. Primary Data (Direct)

   Primary data is data obtained directly from papers related to this research. The data needed is:

   a. Papers distribution
   b. Papers publication per years
   c. Electronic database publisher

2. Secondary Data (Indirect)

   Secondary data is data obtained indirectly, in the form of data obtained from various reliable sources. In this research secondary data used was obtained from journals, reports, modules, books, and websites related to the problems raised in this research.

3.2.2 Processing Data

In this research after data is obtained, it will be processed using SLR (systematic literature review) method. Figure 3.1 will be shown the flow of research conducting the SLR method.

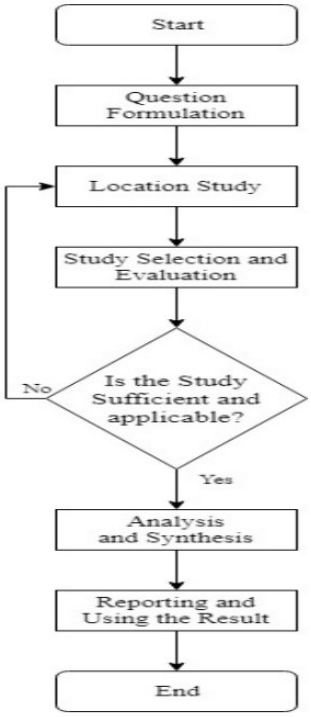

Figure 3. 1 Flow Steps of conduction SLR (Systematic Literature Review)

The research start from question formulation in order to know the objective of the research. Then will be preceded to the locating study, study selection and evaluation order to find related studies of the topic. The collected data will be selected and evaluated, if the papers is can be relevant to support the study then it will transfer to next stage but if the papers is not relevant then recollecting paper is needed. The appropriate studies then will be synthesized and analyzed in order to get a proper result. In the end, the result of reporting stage will be used as the reference for further research.

In processing data, the researcher used some tools in synthesizing and analyzing the relevant papers, which are mentioned below:

A. Microsoft Excel®

   This tool is used for synthesis of data and paper. The formula used is basic formula to sum and make graphics that has been provided by this software.

B. Mendeley Desktop®

   The tool is used to collect and arrange papers, then select and analyze those papers and journals, it also helps to create the references and citations.

C. Visio 2016

   In order to arrange the figure of step, CK-Chart, and other, researcher use VISIO as the tool.

3.3 Data Analysis Method

Analysis and discussion are carried out after processing data using the SLR (systematic literature review) method. Then the results obtained from the research are known to be different from previous research.

3.4 Summary and Suggestion

From analysis already done so the next steps is draw conclusions to answer the objective of the research and provide further suggestion for the development of this research.

CHAPTER IV

SYNTHESIS AND ANALYSIS DATA

This chapter will explain about the data synthesis and data analysis which is a part of literature review. The explanation about method for these analysis and synthesis and how extraction data from several papers to find a new invention related topic.

4.1 Synthesis Data

There are 50 papers suitable with the selection criteria. The papers referred to conducting the SLR method, hazard risk management, risk management process, risk maintenance or strategy, and ISO of risk management. These papers that found, consist of some sub-topic that has correlation among each other which create a framework of hazard risk management focus on maintenance. Below will be shows the synthesis data result that take from paper to conducting systematic literature review. Synthesizing based on sub-topic, publication of journal and year of publication. Each sub-topic contribution, researcher make the percentages, it can be seen in figure 4.1.

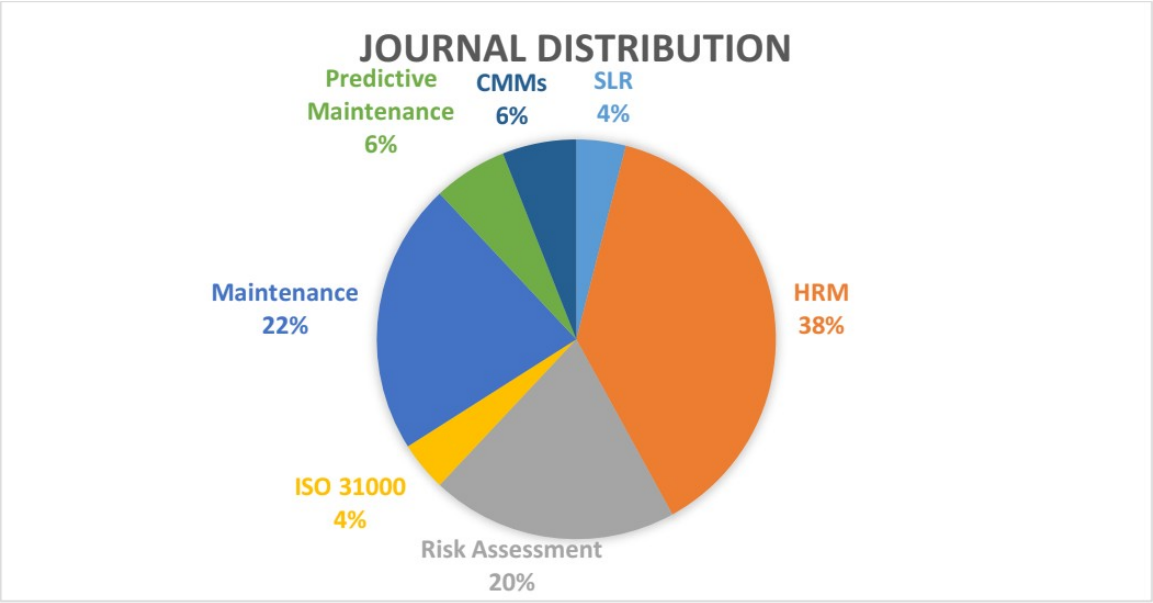

Figure 4. 1 Types of publications

Figure 4.1 shows the distribution of journal complied with SLR method and hazard risk management in maintenance. In this study, there are 4% or 2 papers about SLR scope and with the same amount about ISO 31000 of 50 papers, 22% or 11 papers about maintenance of 50 papers, 20% or 10 papers explain about risk assessment process of 50 papers, 6% or 3 papers about predictive maintenance and with same amount about CMMs or computerized maintenance management system and the last 38% or 19 paper explain about hazard risk management in industry from total 50 papers.

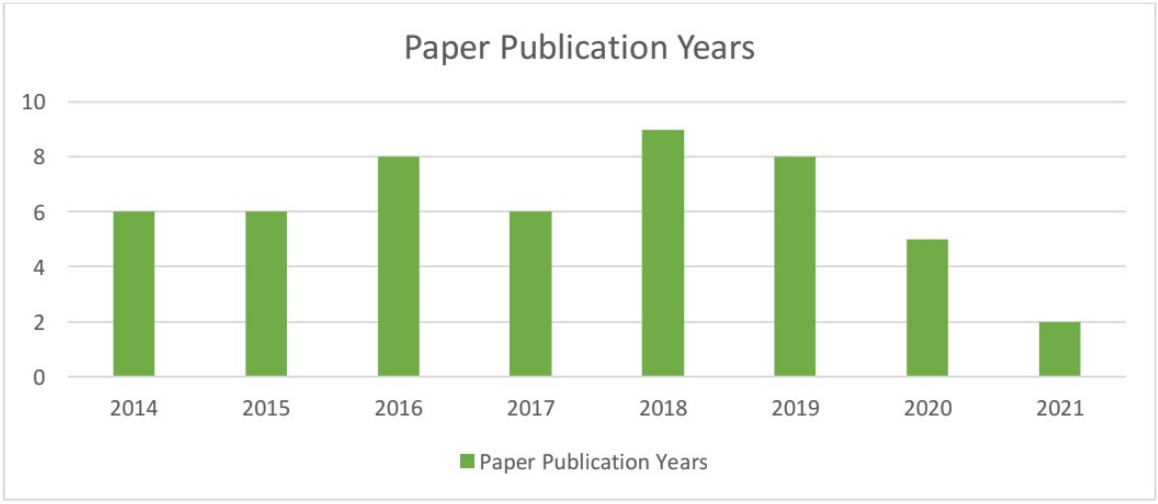

Figure 4. 2 Paper Publication Years

Then on figure 4.2 above shows the publication years, it illustrates the publication years from the paper applied in this research. It employed papers that taken from 2014 – 2021. From the 2014 6 papers were taken for the research, 6 papers from 2015, 8 papers from 2016, 6 papers from 2017, 9 papers from 2018, 8 papers from 2019, 5 papers from 2020, and the last from 2021 taken 2 papers.

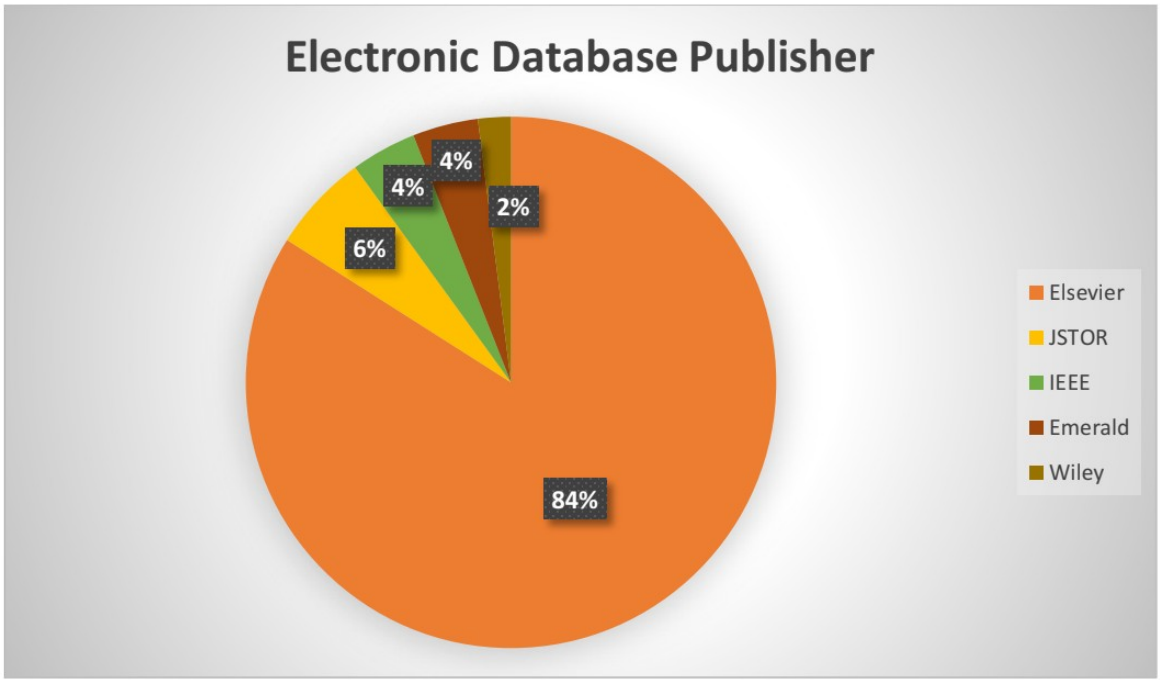

Figure 4. 3 Electronic Database Publisher

After that, on figure 4.3 shows the electronic database publisher of papers that applied with the total papers are 50 papers that used in this thesis. In terms number of publication paper, Elsevier (sciencedirect.com) it most commonly with the amount 42 papers. Second, there are 3 papers from JSTOR (jstor.org). Then IEEE (ieee.org) and Emerald Insight (emerald.com) have taken same amount, there is 2 papers. And Wiley (wiley.com) take 1 paper.

After that, on figure 4.4 shows the number of publications for each publisher. In this study take 29 number of publication for each publisher. In term of number of publications for

each publisher, safety science is most commonly with amount 8 papers. Second, there is 3 paper from process safety & environmental protection and journal of loss prevention in the process industries with same amount. Then amount of 2 papers from journal of environmental management, international journal of disaster risk reduction, procedia engineer, and etc.

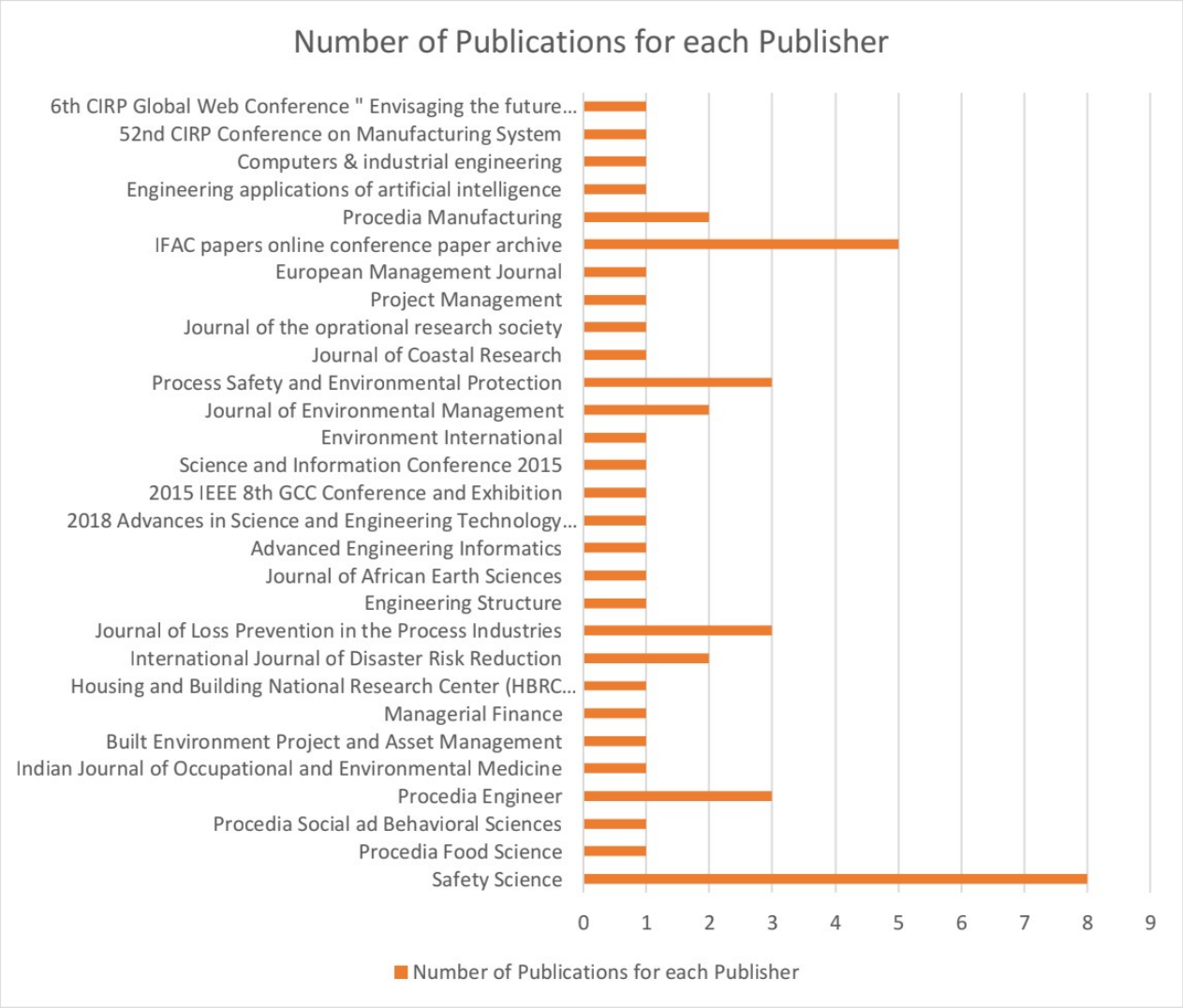

Figure 4. 4 Number of Publications for each Publisher

Then in order to find further research recommendation to explore better solution of hazard risk management in maintenance, researcher also classifies findings into their papers scope, as mentioned in Table 4.1 below.

Table 4. 1 Implementation of SLR Method and Hazard Risk Management Paper Findings

Topic	Years	Author	Electronic Publication Database	Publication Journal	Title
Conducting SLR Method	2015	Faisal Khan, Samith Rathnayaka, and Salim Ahmed	Elsevier	Process Safety and Environmental Protection	Methods and Models in process safety and risk management: Past, Present, and Future
	2019	Priscila Ferreira de Araújo Lima, Maria Crema, and Chiara Verbano	Elsevier	European Management Jornal	Risk Management in SMEs: A Systematic literature review and future
Hazard Risk Management	2014	A. M. Saedi, J. J. Thambirajah, Agamuthu Pariatamby	Elsevier	Safety Science	A HIRARC Model for Safety and Risk Evaluation at a Hydro electronic Power Generation Plant
	2015	Irina Chernukha, Oxana Kuznetsova, Viktoria Sysoy	Elsevier	Procedia Food Science	Hazard Analysis and Risk Assessment in Meat Production practice in Russian Federation
	2017	B. K. Rout, B. K. Sikdar	Willey	Indian Journal of Occupational and Environmental Medicine	Hazard Identification, Risk Assessment, and Control Measures as an Effective Toll of Occupational Health Assessment of Hazardous Process in an Iron Ore Pelletizing Industry
	2018	Valeria Casson Moreno, Valerio Cozzani	Elsevier	Safety Science	Integrated Hazard Identification within the Risk Management of Industrial Biological Process
	2016	HOU Zhin-qiang, ZENG Ya-mei	Elsevier	Procedia Engineering	Research on Risk Management Technology of the

					Major Hazard in Harbor Engineering
	2018	Ragab ElSayed Rabeiy, Mohammed Ragairei ElTahlawi, Gamal Yehia Boghdady	Elsevier	Journal of African Earth Sciences	Occupational Health Hazard in the Sukari Gold Mine, Egypt
	2014	C.A. Velasquez, O.D. Cardona, M.L. Carreno, A.H. Barbat	Elsevier	International Journal of Disaster Risk Reduction	Retrospective Assessment of Risk from Natural Hazard
	2018	M.H. Crawford, K. Crowley, S.H. Potter, W.S.SA. Saunders, D.M. Johnston	Elsevier	International Journal of Disaster Risk Reduction	Risk Modelling as a tool to support Natural Hazard Risk Management in New Zealand local government
	2014	Sabarethinam Kameshwar, Jasmie E. Padgett	Elsevier	Engineering Structure	Muti-hazard risk assessment of highway bridges subjected to earthquake and hurricane hazard
	2016	Quanlong Liu, Xianfei Meng, Maureen Hassall, Xinchun Li	Elsevier	Safety Science	Accident-causing Mechanism in Coral Mines based on Hazards and Polarized Management
	2016	Manuel Rodriguez, Ismael Diaz	Elsevier	Journal of Loss Prevention in the Process Industries	A Systematic and Integral Hazard Analysis Technique Applied the Process Industry
	2014	Amotz Perlman, Rafael Sacks, Ronen Barak	Elsevier	Safety Science	Hazard Recognition and Risk Perception in Contraction

	2016	Jelena M. Andric, Da-Gang Lu	Elsevier	Safety Science	Risk Assessment of Bridges Under Multiple Hazards in Operation Period
	2017	O.N. Aneziris, Z. Nivolianitou, M. Konstandinidou, G. Mavridis, E. Plot	Elsevier	Safety Science	A Total Safety Management Framework in case of a Major Hazards Plant Producing Pesticides
	2015	Emmanuel A. Gonzalez, Rolly S. Presto, Alexander C. Remacha, and Arnold N. Santos	IEEE	2015 IEEE 8th GCC Conference and Exhibition	A Model Describing Hazard Identification Effectiveness of Workers in the Construction and Maintenance Industry
	2019	Nicholas Chartres, Lisa A. Bero, and Susan L. Norris	Elsevier	Environment International	A Review of Method used for Hazard identification and Risk Assessment of Environmental Hazard
	2017	Ozge Yilmaz, Bahar Y. Kara, Ulku Yetis	Elsevier	Journal of Environmental Management	Hazardous Waste Management System Design under Population and Environmental impact considerations
	2019	Xinhong Li, Guoming Chen, Yuanjiang Chang, Changhang Xu	Elsevier	Process Safety and Environmental Protection	Risk-based Operation Safety Analysis during Maintenance Activities of Subsea Pipelines
	2018	Gonzalo Malvarez, Fatima Navas, Dennis J. Parker, Edmund	JSTOR	Journal of Coastal Research	The Need for Coastal Hazard Prevention and its Valuation

		Penning-Rowsell			Methodologies in Europe
Risk Assessment or Risk Management Process	2014	W.M.P.U. Wijeratne, B.A.K.S. Perera,L. De Silva	Emerald	Built Environment Project and Asset Management	Identification and assessment risks in maintenance operations
	2014	Frank Bezzina, Simon Grima, Josephine Mamo	Emerald	Managerial Finance	Risk Management practices adopted by financial firms in Malta
	2017	Mohamed Sayed Bassiony Ahmed Abd El-Karim, Omar Aly Mosa El Nawawy, Ahmed Mohamed Abdel-Alim	Elsevier	Housing and Building National Research Center (HBRC Journal)	Identification and Assessment of risk factors affecting construction projects
	2016	Zuraini Jusoh, Noristisarah Abd Shattar, Hayati Adilin Mohd Abd Majid, Nur Dalila Adenan	Elsevier	Procedia-Social and Behavioral Sciences	Determination of Hazard in Captive Hotel Laundry Using Semi Quantitative Risk Assessment Matrix
	2018	Xiaoyan Guo, Laibin Zhang, Wei Liang, Stein Haugen	Elsevier	Journal of Loss Prevention in the Process Industries	Risk Identification of third-party damage on oil and gas pipelines through the Bayesian Network
	2017	Pawel Szywanski	Elsevier	Procedia Engineering	Risk Management in Construction Projects
	2017	John Lathrop, Barry Ezell	Elsevier	Safety Science	A Systems approach to risk analysis validation for risk management

	2016	F. Brocal, M.A. Sebastian, C. Gonzalez	Elsevier	Safety Science	Theoretical framework for the new and emerging occupational risk modelling and its monitoring through technology lifecycle of industrial
	2018	Albara M. Mustafa and Aziz Al-Mahadin	IEEE	2018 Advances in Science and Engineering Technology International Conferences (ASET)	Risk Assessment of Hazards Due to the Installation and Maintenance of Onshore Wind Turbines
ISO 31000	2016	A.Olechowski, J. Oehmen, W. Seering, and M. Ben-Daya	Elsevier	Project Management	The Professionalization of Risk Management: What role can the ISO 31000 risk management principles play?
	2015	Antonio Augusto Sepp Neves, Nadia Pinardi, Flavio Martins, Joao Janeiro, Achileas Samaras, George Zodiatis, Michela De Dominics	Elsevier	Journal of Environmental Management	Toward a common oil spill risk assessment framework-Adapting ISO 31000 and addressing uncertainties
Maintenance	2018	Xuzhong Yan, Heng Li, Hong Zhang, Timothy M. Rose	Elsevier	Advanced Engineering Informatics	Personalized Method for Self-management trunk postural ergonomic hazards in construction rebar ironworks
	2016	Payam Amir-Heidari, Reza Maknoon,	Elsevier	Journal of Loss Prevention in	Identification of Strategies to Reduce Accidents

		Bahram Taheri, Mahdieh Bazyari		the Process Industries	and Loss in Drilling Industry by Comprehensive HSE Risk Assessment- A Case Study in Iranian Drilling Industry
	2015	Maryam Gallab Lerma, Hafida Bouiz, and Mohamed Tkiouat Lerma	JSTOR	Science and Information Conference 2015	Decision Support for occupational Risk Overcome in Maintenance Activities
	2019	Xinhong Li, Guoming Chen, Yuanjiang Chang, and Changhang Xu	Elsevier	Process Safety and Environmental Protection	Risk based operation safety analysis during maintenance activities of subsea pipelines
	2019	VM Rao Tummala, CL Mak	JSTOR	Journal of the oprational research society	A risk management model for improving operation and maintenance activities in electricity transmission networks
	2020	Fernada F. Alves, Martin G. Ravetti	Elsevier	IFAC papers online conference paper archive	Hybrid proactive approach for solving maintenance and planning problem in the scenario of industry 4.0

	2021	Gianpaolo Di Bona, Vittorio Cesarotti, Gabriel Arcese, Tommaso Gallo	Elsevier	Procedia	Implementation of Industry 4.0 technology: New opportunities and challenge for maintenance strategy
	2020	Chiara Cimino, Alberto Leva, Elisa Negri, Marco Macchi	Elsevier	IFAC papers online conference paper archive	An Integrated simulation paradigm for lifecycle-covering maintenance in the Industry 4.0 context
	2020	Mirka Kans, Jaime Campos, Lars Hakansson	Elsevier	IFAC papers online conference paper archive	A remote laboratory for Maintenance 4.0 training and education
	2021	Tommaso Gallo, Annalisa Santolamazza	Elsevier	Procedia	Industry 4.0 and Human factor: How is technology changing the role of the maintenance operator?
	2019	Malgorzata Jasiulewiez, Kaemarek, Arkadiusz Gola	Elsevier	IFAC papers online conference paper archive	Maintenance 4.0 technologies for sustainable manufacturing- an overview
Predictive Maintenance	2019	B. Einabadi, A. Baboli, M. Ebrahimi	Elsevier	IFAC papers online conference paper archive	Dynamic predictive maintenance in Industry 4.0 based on real time information: Case study in automotive industries

	2020	Tiago Zonta, Cristiano Andre da Costa, Rodrigo da Rosa Righi, Miromar Jose de Lima, Eduardo Silveira da Trindade, Guann Pyng Li	Elsevier	Computers & Industrial Engineering	Predictive maintenance in the Industry 4.0: A systematic literature review
	2020	Jose-Raul Ruiz-Sarmiento, Javier Monroy, Francisco-Angel Moreno, Cipriano Galindo, Jose-Maria Bonelo, Javier Gonzalez-Jimenez	Elsevier	Engineering Applications of Artificial Intelligence	A Predictive model for the Maintenance of industrial machinery in the context of Industry 4.0
CMMs or Computerized Maintenance Management system	2016	Isabel Lopes, Patricia Senra, Sandrina Vilarinho, Vera Sa, Catarina Teixeira, Joao Lopes, Anabela Alves, Jose A Oliveira, Manuel Figueiredo	Elsevier	Procedia CIRP	Requirement specification of a computerized maintenance management system- a case study
	2019	H. komoto, S. Kondoh, Y. Furukawa, H. Sawada	Elsevier	52nd CIRP conference on manufacturing system	A simulation framework to analyse information in a Smart Factory with focus on run-time adaptability of machine tools

	2018	Patrik Munyensanga, Susilo A. Widyanto, Moh. N. A. Aziz, Rusnaldy Paryanto	Elsevier	6th CIRP Global web conference " Envisaging the future manufacturing , design, technologies, and system in innovation era"	Information Management to Improve the effectiveness of Preventive Maintenance activities with Computerized Maintenance Management System at the intake system of circulating water pump

4.2 Data Analysis

Based total 50 papers that related to research topic, which are SLR method, hazard risk management, risk management process or risk assessment, ISO 31000, and maintenance 4.0. These papers are selected using SLR method. A SLR is means of identifying, evaluating, and interpreting available research relevant to a particular research question or topic area. Then researcher have sub-topic of the research which hazard risk management framework focusing on maintenance and the framework of the use SLR. In sub-topic of hazard risk management focusing on maintenance. The framework of conducting SLR method will be seen below on figure 4.5.

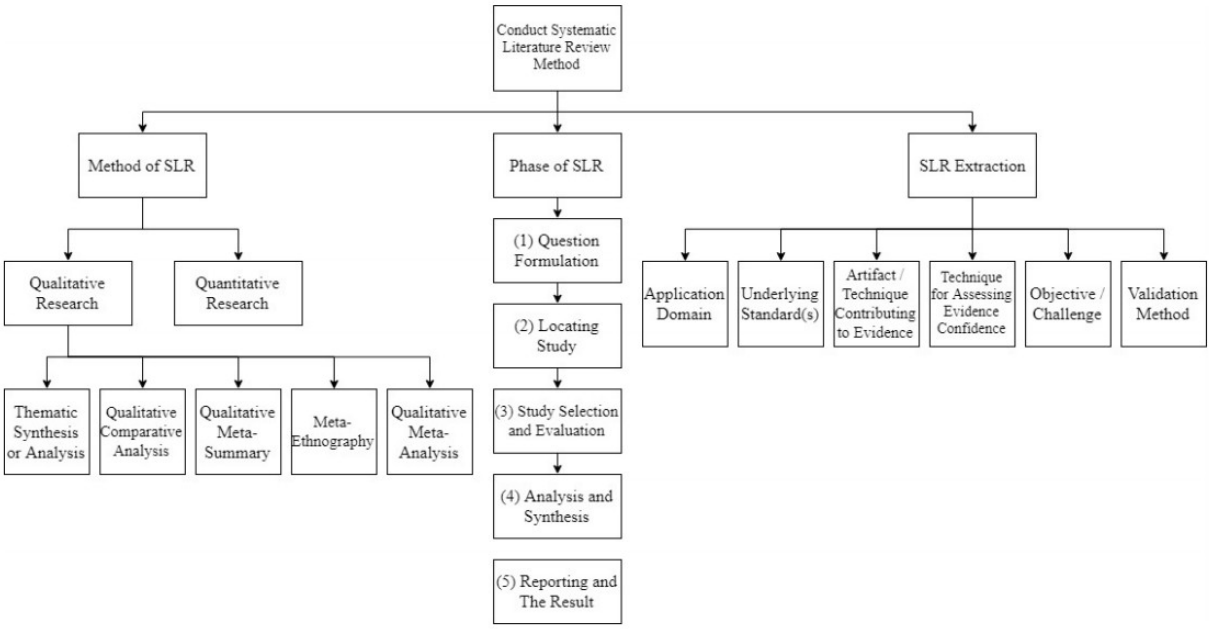

Figure 4. 5 Conduct SLR Method Framework

Figure 4.5 shows the framework about SLR method, with consist of technique method in SLR, phase of SLR extraction. It shows that are some technique method that can use on SLR that are qualitative and quantitative. In qualitative scope, divide into various methods can be included to perform systematic literature review which are thematic synthesis or analysis, qualitative comparative analysis, qualitative meta-summary, meta-ethnography, qualitative meta-analysis (Garza-Reyes, 2015). In this research, the researcher using qualitative research with thematic synthesis analysis. Then the phase of SLR and extraction will discuss on below.

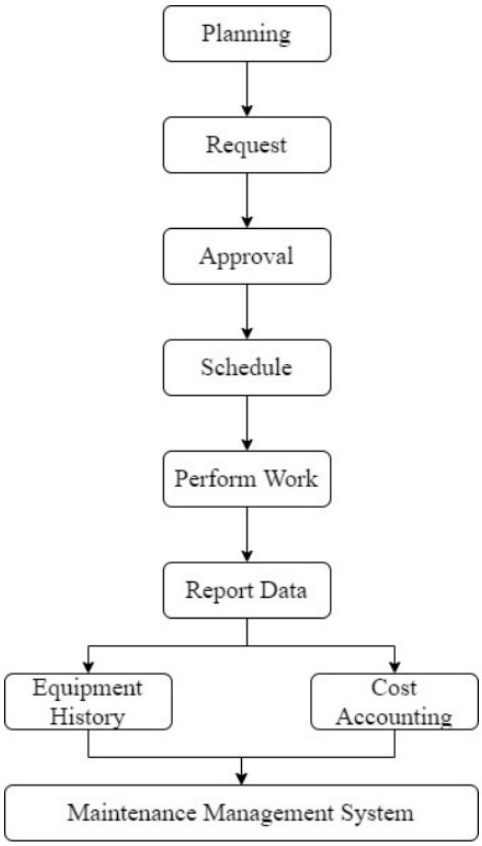

Figure 4. 6 Maintenance Management Framework

Figure 4.6 shows the sub-topic of studies that create a framework of maintenance management framework. It shows that some aspects that must be considered to create maintenance management. Below is a short explanation of the contribution of each sub-topic in order to creating a maintenance management framework.

In maintenance division the first action is planning its means the staff or operator for maintenance division create the planning from any machine in company. After that making the request for manager maintenance to approve the planning maintenance. Then after manager approve the planning the next step is create the schedule for maintenance to make scheduling for machines.

The next step is perform work or action of maintenance, is means the operator of maintenance have activity maintenance for repair machines. Next step is report data in this step have two activity. First, equipment history in this step consist data for equipment or material used in maintenance activity to repair some machine. Second, cost accounting in this step create calculate the cost in maintenance and make billing to payment the cost of equipment or material already used. The last is maintenance management system in this step the all data to make historical data for maintenance.

The maintenance management framework is limited to repairing and maintaining machinery or equipment related to production, while hazard risk management refers to identifying risks for all activities in the company. Not only internal but also external; risks that can disrupt the company's, manage these risks that they can be controlled and don't interfere with the business process in a company.

Thus, to apply hazard risk management framework focuses on maintenance the aspects that need to be considered are risks that can disrupt the production line, resulting in engine stopping or idle time. In addition, the safety of the operator maintenance is very important in this case because the risk to repair the machine is biggest, it will be very risky for the safety of the maintenance operator. In hazard risk management focuses on maintenance, it must also pay attention to risks that are un-scheduling the maintenance so that they can be controlled or avoided. For more details, an illustration of the hazard risk management framework focus on maintenance can be seen in Figure 4.7 below.

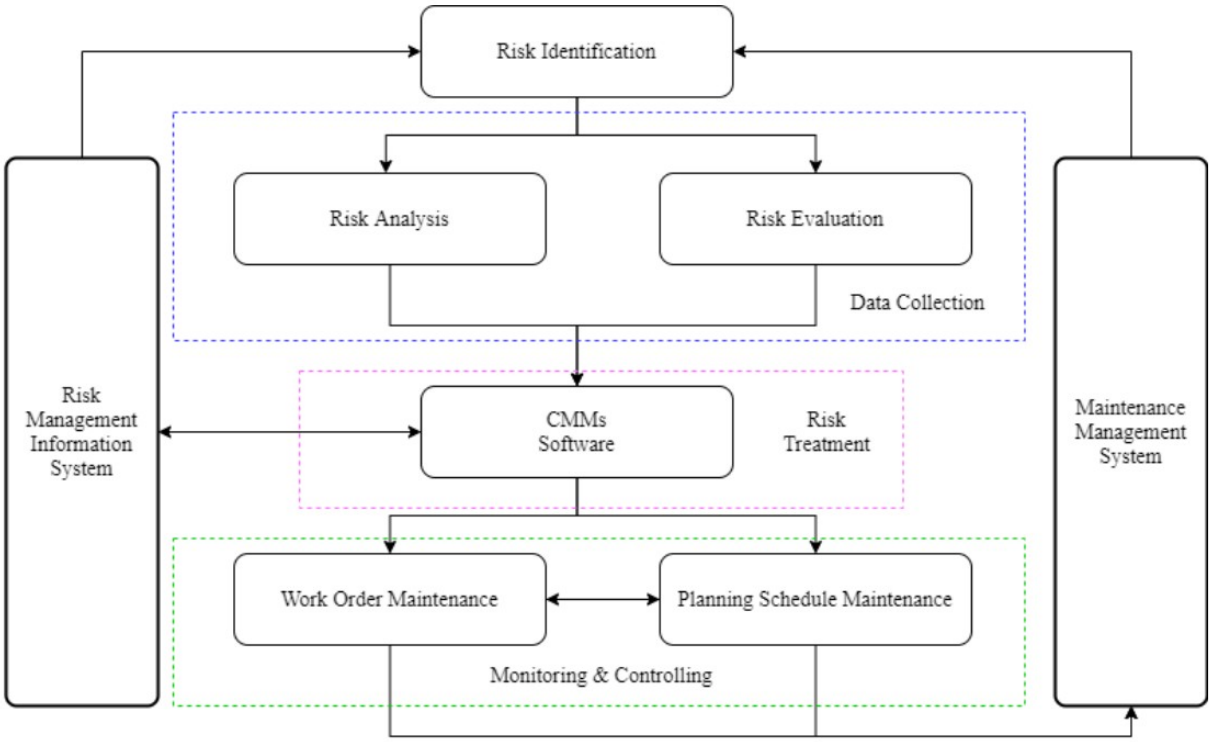

Figure 4. 7 Hazard risk management Framework for Maintenance

Figure 4.7 shows the sub-topic of studies that create a framework of hazard risk management for maintenance. It shows that some aspects that must be considered to create a hazard risk management framework focusing on maintenance. Below is a short explanation of the contribution of each sub-topic in order to creating a hazard risk management framework focusing on maintenance.

This framework is combine two framework (maintenance management framework and hazard risk management framework) to create this framework. The research create this framework to proposed hazard risk management focus on maintenance. That means the researcher make improve for maintenance research previous.

This framework consists of several phases in hazard risk management. The first step is risk identification. In this step, identify potential risks from all unexpected events in the

company's activities, both internal and external. The next step is risk analysis, after the risk is identified, then the risk must be assessed as a potential loss and the possibility of an occurrence that can interfere with the company's activities or create a loss for the company. In risk analysis, there are two perspectives, namely the impact or consequences and likelihood or frequency.

In impact is the risk that will be assessed as an impact or whether the risk has an impact on the company by giving a value of 1-5 for the number 1 is the lowest value or has almost no impact on the company or is still within the company's tolerance limit. Then the risk will be assessed by likelihood or frequency by assessing how often this risk appears in a certain period or within a certain time.

The next step is the risk evaluation this step to determine the risk that exceeds the company's risk tolerance or not and sort out the risk priorities for the maintenance plan. In this step, the risks will be arranged according to priority. If the risk priority is high, then the risk will greatly disrupt the running of the company or production so that the company will experience the risk of very large and unexpected losses. But if the risk does not exceed the tolerance limit, it means that the risk can be handled or eliminated without disrupting the running of the company.

Then the risk treatment in this step is to treat the risk. In this research, risk treatment uses the help of CMMs or a computerized maintenance management system. This software is used to simplify maintenance work in the maintenance era 4.0. The way this software works or CMMs is to use a comparison of 2 data, namely the data when the normal machine is taken from the risk management information system and data when there is a risk or unexpected event. After the data is entered, this software will analyse the 2 data as a standard or benchmark for running the application so that when the operator updates the data from the machines if

there is odd data, the software will automatically provide reports or warnings to the maintenance division and will issue a maintenance work order regularly direct.

The next step is monitoring & controlling. In this step, there are 2 outputs from the previous step, namely, work order maintenance and planning schedule maintenance. If there is any odd data, CMMs will immediately issue a maintenance work order to the related division. In the maintenance work order, there will be details about which machines need to be maintained and what to be maintained. Then after that, the operator or the maintenance division will make a maintenance planning schedule to handle the machines that need to be repaired. After everything has been done, the data will be entered into the maintenance management system to be stored as big data maintenance. In risk management information system the data can update or create for relevant division.

4.2.1 Conduct Systematic Literature Review Identity

Researcher performed study selection and evaluation on published in academic journals and proceeding of international conferences. Researcher found that discuss about the way to conduct SLR method by 2 papers, consist of Priscila et.al. (2019) and Faisal et.al. (2015). The extracted findings of SLR identity can see on table 4.2. All of research above, use SLR method in according to Tranfield et.al. (2003), Khan et. al. (2003), and Fink (2014), which has five phase processes. First is formulating topic. Second is selecting location studies of journal article. Third, the researcher performs study selection and evaluation. Hence, if research string is valid, researcher can be continuing the phase, that is synthesis and analysis. In the end of phase, fifth, this research has find research.

Table 4. 2 Extracted Data for the use of SLR findings

Authors	Topic Domains	Location Studies	Journal Period	Keyword Use	Findings
Priscila et.al. (2019)	Development and the state of the art of RM in SMEs.	Science Direct, Emerald, Fulltext, JSTOR, Willey, and Online Library	First period 1994 – 2006 Second period 2007 - 2016	"Risk Management" "SMEs" "Systematic literature review" "Bibliometric analysis" "Research Agenda"	Risk Management, SMEs, Bibliometric Analysis, Systematic Literature Review, Strategy Perspective, Manage Strategy Risk
Faisal et.al. (2015)	Provide a historical development with respect to the driving forces.	Science Direct, Emerald, Google Scholar, JSTOR, IEEE, Willey, and Online Library	1990 - 2012	"Process safety" "Risk assessment" "Inherent safety" "Dynamic risk" "Accident model" "Safety management"	Historical Development, Process Safety, Risk Management, Process Hazard, Risk Analysis, Dynamic Risk Assessment, Quantitative and Hybrid Development
Akhigbe et.al. (2017)	Health Care-Brain Arteriovenous Malformation (AVM)	Medline, Embase	1st of May 2011 and 30th April 2016	"SLR", "Meta-analysis", "Human Studies", "Brain AVM Management", " PRISMA"	Examined the article with PRISMA statement guidelines

SLR is increasingly used on many research to critically appraise and summarize all empirical evidence from multiple research studies or papers. SLR method can use on several domains of research to more evaluate and review in further problem. The application domains such as food, medical, financial, SCM, automotive, robotics, maritime, and others (Nair et.al., 2014). The example use of SLR is on Faisal (2015) research, with evaluate and review sample

of the literature relating to provide a historical development with respect to the driving forces and suggest future directions.

Then, SLR become significance in Akhigbe et.al. (2017) research with health care problem, where their research is to compliance of SLR articles in brain arteriovenous malformation (AVM). They developed compliance SLR using meta-analyses based QUORUM Guidelines, once used by Moher D. et.al. (1999). This study was updated by the preferred Reporting Items for Systematic Review and Meta-analyses statement (PRISMA) (Moher D. et.al., 2009). PRISMA provides a guideline of twenty-seven items that are recommended in order to be equipped to review or appraise existing literatures based on known deficit to look for or expect. It will improve quality and full reporting of systematic reviews ultimately improving quality of evidence in the management of brain AVM. Where, first they take strictly filter the papers on Medline (4236 papers) and Embase (2407 papers) as journal publisher relate brain AVM. Then find the 23 papers of the total paper, which was considered feasible full-text relevant to the focus and years of the papers, they finally got the 7 papers where the papers are also use SLR in research methods. Finally, the mean percentage result of applicable PRISMA items that were met across all studies was 74 %(range 67 – 93%). This showed that systematic review published in leading do not necessarily comply fully with all domain of PRISMA statement guidelines.

Then the next research from Priscila (2019) which revealed about SLR with risk management in SMEs. This paper have aims is to outline the development and the state of the art of risk management in SMEs, grasping new future research opportunities in this field. In papers doing research with second period for analysis, the first period for analysis in 1994 – 2006 this period the researcher get 11 papers. Second period for analysis in 2007 – 2016 in this period researcher also get 50 papers to use in this research. The result of this paper is contribute

to structure the risk management themes developed in the literature for SMEs. This paper suggests an original research methodology approach that provides a contribution to the development of a combined methodology for conducting literature reviews.

4.2.2 Hazard Risk Management for Maintenance

From total 38 papers complied with selection criteria, it selected which correlated with hazard risk management for maintenance only 4 papers. In the following selections, will be explanation from figure 4.6 above. In figure 4.6 shows the process of hazard risk management a related to maintenance, because be found step or process already explanation in above of this research so researcher will be explain from risk evaluation, risk monitoring & controlling, and maintenance management system.

4.2.2.1 Risk Evaluation

a. Solution Generation

The solution generation stage which consists of ranking the identified risk factors, developing risk control action plans, establishing risk control costs, and selecting the best course of action (Gallab, Bouloiz, & Tkiouat, 2015). The ranking of risk factors consists of finding risk exposure values and prioritizing the identified risk factor based on these risk exposure values. Similarly, developing risk control action plans involves formulating possible risk response actions to contain and control the identified risk factors based on five risk control approaches namely, accept, reduce, avoid, spread, and transfer (Tummala & Mak, 2018).

b. Requirement & Criteria

The strategy of reducing risk involves assessing risk severities and/or risk probabilities. Avoiding risk means changing the situation so that the concerned risk factors may no longer be applicable. The fourth strategy of spreading or distributing risk deals with modifying the situation or taking remedial actions to lower the risk severity and/or risk probability levels, and to accept the associated risks. Finally, the strategy of risk transfer involves transferring risks by taking insurance protection. Establishing risk control costs stage consists of examining the resources needed and determining the associated costs to full implement the formulated risk response action plans (Amir-Heidari, Maknoon, Taheri, & Bazyari, 2016).

4.2.2.2 Risk Monitoring and Controlling

The risk monitoring and controlling phase consists of reviewing the progress off all risk management activities. One of the major tasks is to monitor the established risk targets by continuously updating the risk exposure values. If any deviations to established targets would occur, corrective actions need to be taken to achieve the desired objectives of the project. Some of the risk control plans that are implemented to contain risks may require training. These training needs and how they are provided, should be continuously monitored and updated (Tummala & Mak, 2018). This phase involves recording and communication the relevant information on the status of risk control action plans or projects for the identified risk factors to senior management. As explained in the risk management model section, any training needs and emergency preparedness plans required to implement risk control action plans must also be monitored. In addition, appropriate risk management audit plans and the corresponding audit checklists to evaluate the performance of the overall risk management needs to be monitored and updated if necessary (Chernukha et al., 2015).

4.2.2.3 Risk Management Information System

The risk management information system phase involves collecting information on the identified risk factors including consequence severities and risk probability levels, risk exposure values and establishing the corresponding database system. In additional, the information on all risk control action plans (or projects) must be stored in the risk management information system databases. Similarly, training needs, audit and maintenance checklists, and supplier specifications on equipment and other pertinent information related to all risk control action plans must be kept in the maintenance management system. It is important to establish a maintenance management information system that will interface for easy transfer and accessibility with the maintenance management system, and the other existing systems like health and safety management system, and operation integrated maintenance system (Tummala & Mak, 2018).

CHAPTER V

RESULT AND DISCUSSION

This chapter discuss the research in a whole discuss problem of hazard risk management and discuss the data analysis from study literature review (SLR) phases.

5.1 Conduct Systematic Literature Review

Systematic review focuses on a specific research with a duplicate methodology to identify, critically appraise and summarize all empirical evidence from multiple research studies or papers. Systematic and meta-analyses have become increasingly of great significance in health care. The reporting transparency of systematic review is important to the readers to be able to assess the conduct and quality of the review (Fink, 2014). According to Garza-Reyes (2015) stated that various methods can be included to perform systematic literature review are thematic synthesis or analysis, qualitative comparative analysis, qualitative meta-summary, meta-ethnography, qualitative meta-analysis. In this research, the researcher using qualitative research with thematic synthesis analysis.

More profoundly about SLR, Nair et.al. (2014) extracts its research on extended SLRs on provision of evidence for safety certification. In this research process, Nair extends the discussion into some of required SLR data, as in Table x. Then, to increase the validity of the SLR research, they suggest the following: (1) limit knowledge venue to avoid publication bias, (2) selection of primary studies, (3) data extraction. In data extraction contains several information to show the deepness of paper that researcher use. The example of data extraction from Nair (2014) research will shows on Table 5.1 below.

Table 5. 1 The Example of Extraction Data on SLR method

Bibliographic Information	Application Domain	Underlying Standard (s)	Artefact/technique contributing to evidence	Technique for assessing evidence confidence	Tool Support	Objective/Challenges	Validation Method
Name of researcher	Automotive, Railway, Oil, Energy, Food, etc.	UK defence standard 00–56, and compare them with civil standards such as DO-178B, ARP4754, ARP4761, and IEC 61508. Dittel & Aryus (2010) discuss the challenges of interpretation, implementation, and identification of the right level of detail when building safety cases for compliance with ISO 26262	Qualitative Assessment, Checklist, Logic Based Assessment	Argumentation, Model, or Textual Template	Which assists in the provision of evidence (collection, structuring, and assessment) for certification or safety Assurance purposes.	Specification of evidence content; Construction of safety cases; Capturing the degree of credibility or relevance of the evidence; Better development processes and better evidence about process Compliance; Ambiguities of safety standards; Demonstration of compliance for novel technologies; and First-time certification or recertification of ‘‘proven-in-use’’ systems	The studies were classified as: case study (validated during projects by practitioners different from the authors), field study (validated with data from real projects, but not during the execution of the projects), action research (validated during real projects by the authors themselves), survey (validated on the basis of practitioners’ opinion and perspectives), or none.

After the discussion above, the researcher can make the framework of conducting the SLR method. The framework to use the SLR method can shows on Figure 5.1.

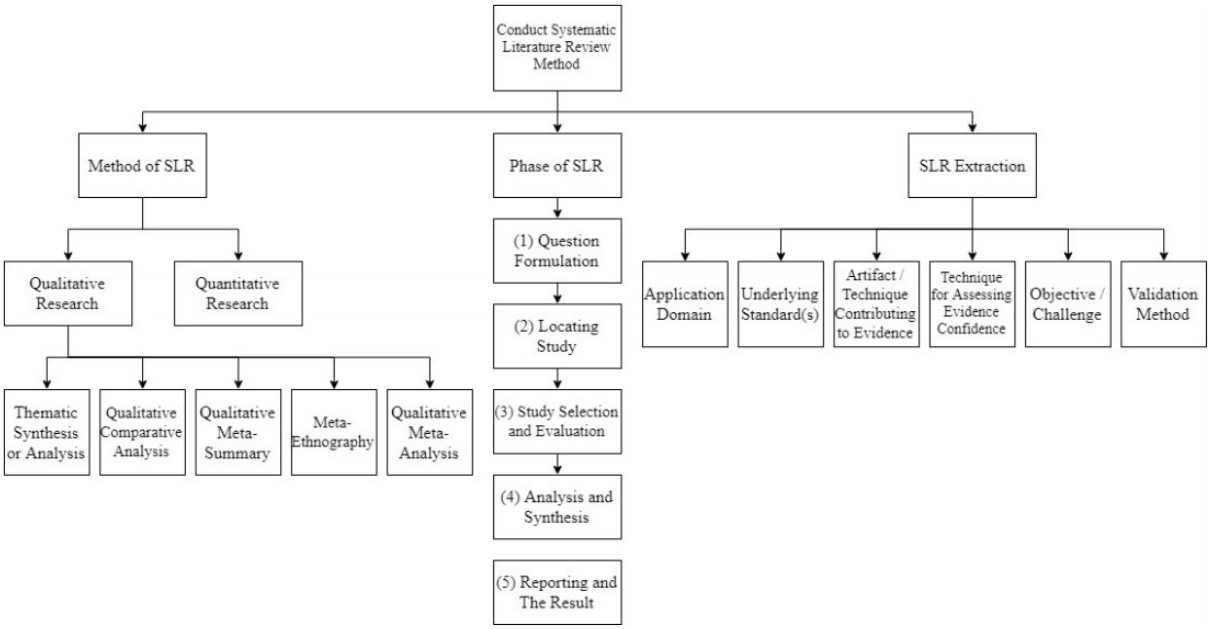

Figure 5. 1 Framework for Conduct SLR method

Although have a different object in research, many researchers such as Lima et.al. (2019) and Khan et.al. (2015) had been follow the step phase to conduct the SLR by Fink (2014), which consist of question formulation, locating studies, study selection and evaluation, synthesis and analysis, then reporting.

Then, the extraction data for this research will be shown in Table 5.2, where the application domain is hazard risk management, the standard is using ISO 31000 for guide the hazard risk management process.

Table 5. 2 Extraction Data for this research

Application Domain	Underlying Standard	Information / artefact / technique contributing to evidence	Technique for assessing evidence confidence	Tool Support	Objective / Challenges	Validation Method
Hazard risk management on maintenance 4.0	Risk management model and standard risk management: ISO 31000	Qualitative research	Thematic Synthesis Analysis	Microsoft Excel, Mendley Desktop, CK-Chart, Visio	Implementation hazard risk management framework on maintenance activities with standard ISO 31000	None

5.2 Hazard Risk Management framework on Maintenance activities

Maintenance has become an essential function and a primordial necessity in industrial activities of all sectors as well as the functions of production, quality, safety, human resources, and etc. Nevertheless, although the essential nature of the maintenance operation is more widely recognized, maintenance activities are identified for a long time as critical tasks for operator's safety. Several studies have shown that more than three-fourths

of maintenance related accidents could have been avoided if appropriate preventive measure had been put in place. Therefore, safety during maintenance activities is most important aspect to be considered. Risk analysis during maintenance is required to improve the completion probability of operations, and avoid unexpected incidents.

There are some researches explains about the hazard risk management, especially for hazard risk management on maintenance activities. This study will try constructing the framework of hazard risk management a related to maintenance activities. Finding the good framework of hazard risk management can be helped by SLR. It can ensure a rigorous review or research result. Existing contributions on hazard risk management will be systematically collected and critically analysed by SLR in order or make a good framework of hazard risk management in maintenance activities.

Researcher to finding the good framework of hazard risk management can be helped by SLR. It can ensure a rigorous review or research result. Existing contributions on hazard risk management about the processed of risk management step since risk identification until the relationship between risk management step and maintenance activities, it will be systematically collected and critically analysed by SLR.

SLR is used to analyse hazard risk management on maintenance activities, the steps to conduct SLR have been explained in chapter two which are question formulation, locating studies, study selection and evaluation, synthesis and analysis, and then reporting. In the end, the report is for further research. The question formulation, location studies and study selection and evaluating have been explained in chapter two and three, and for the synthesis and analysis have been explained in chapter four. The final phase which is reporting and using the result will be explained in this chapter that is chapter five. Question formulation related to SLR

method, thematic synthesis analysis, hazard risk management is the main topic to conduct SLR about the hazard risk management framework on maintenance activities.

The entire papers in this research reviewed are taken Elsevier (sciencedirect.com), IEEE (ieeexplore.ieee.org), Emerald Insight (emerald.com), Wiley (wiley.com), and JSTOR (jstor.org). 50 papers of hazard risk management are selected and separated based on sub-topic of research, publication of the journal, and year of publication. Based on sub-topic of studies consist of 2 articles or 4% about of SLR which consist of technique of SLR, phase of SLR, and extraction of SLR. Then 19 articles or 38% about hazard risk management, 10 articles or 20% explain about risk management process or phase. Next, 2 articles or 4% about parameters of risk management in ISO 31000, 3 articles or 6% about predictive maintenance & CMMs and the last 11 articles or 22% explain about maintenance activities.

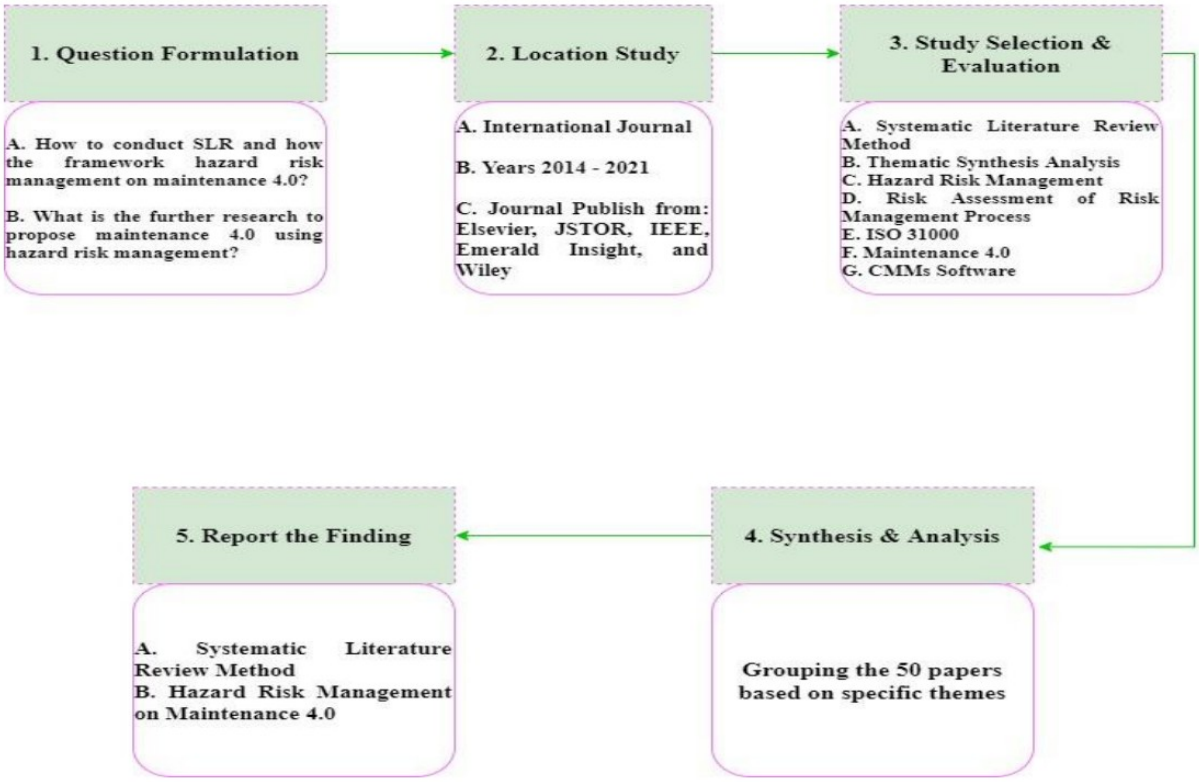

Figure 5. 2 SLR phase and Result in each phase

After using systematic literature review (SLR), which is the papers were synthesized and analysed, whole of papers discusses about hazard risk management with having sub-topic risk management method include risk assessment and ISO 31000, that has been mention and explain in chapter two and four.

This framework is the result of SLR in order to explain the proposed maintenance 4.0 framework using hazard risk management based on ISO 31000. Table 5.3 below will be explain the data should be collected for maintenance framework using hazard risk management based on ISO 31000.

Table 5. 3 The data for Maintenance Framework using Hazard Risk Management based ISO 31000

Hazard Risk Management Process focus on Maintenance	Output Data
a. Risk Identification	➢ Risk List ➢ Type of Risk
b. Risk Measurement	➢ Risk Probability or Likelihood ➢ Risk Impact or Consequences ➢ Level of Risk
c. Risk Evaluation	➢ Risk Map ➢ Risk Priorities List ➢ Risk Response or Risk Treatment
d. Risk Monitor and Control	➢ Risk Management Design ➢ Monitoring Worksheet

	➢ RACI Matrix
e. Maintenance Management System	➢ Routine Schedule for Maintenance ➢ Strategy to handle the Risk on Maintenance ➢ Improved the Risk management

5.3 Risk Identification

Risk identification is first step will be doing in risk management. In the production process consist of many activities that run systematically and arranged, then this risk identification the first thing to do is classification of work activities. To conducting the classification of work activities by creating the detail all work activities in production process. Then, from the detailed data of work activities will be identified each activity to find whether the activity can produce risks or not that will make the production process hampered or stopped. After the all activity already identified so will be made a list of risk from each activity.

Next, .to find out the type or group of risk in each activity for production process so will create the identified the type of risk based on the risk conduct directly or indirectly affect to production process. The detail activity create scenario to find the probability the risk will occurs. The type of risk process doing create group consist of whether the risk directly affect or do not affect to production process. The risk that does not potential affect for production process so risk can be ignored because if this risk happen so the production process should be nothing happen.

5.4 Risk Measurement

The next step after get the list of risk and type of risk is risk probability or likelihood. Risk probability is probability level of risk happen or how often risk occurs compared to certain activity in period based on historical experience or possible future. Risk probability or likelihood is part of risk measurement step so in this step create or measure the probability of each risk will be happen in period time (monthly/weekly). In likelihood there are have five value is rare, unlikely, moderate, likely, and almost certain. The five value already explain in chapter two. After that, the detail activity will be measure in risk impact or consequence. Determine the level or value of likelihood the risk owner can be choose risk based on the nature of activity such as routine, non-routine, possible occur in future, and etc.

Risk impact or consequence have meaning is the level of loss or potential loss arising from an event based on historical experience or possible future. Risk impact or consequence will create for each activity for potential risk. Determine the impact criteria from each event based on the department or section of activities. This risk impact will be determine with table of risk impact or consequence a have five value there is insignificant or none, minor, moderate, major, and catastrophic. If the risk have higher value so the risk level is dangerous and this risk have impact to stop the production process. If in measure the risk impact or consequence, the activity have more than one risk so the risk owner or someone who take a decision can choose one impact the most dominant or significant risk.

5.5 Risk Evaluation

Risk evaluation is refers to determining whether the risk exceeds organizational or not and priorities for the treatment or response plan. Output from this step is risk map and priority of

risk list. Risk map is graphical representation of risk events on the basis of the level impact and likelihood in a particular business unit. Risk map have objective is used to indicate risk position and determine risk response priorities. Figure 5.3 show the risk map for example of risk matrix to identify the risk value.

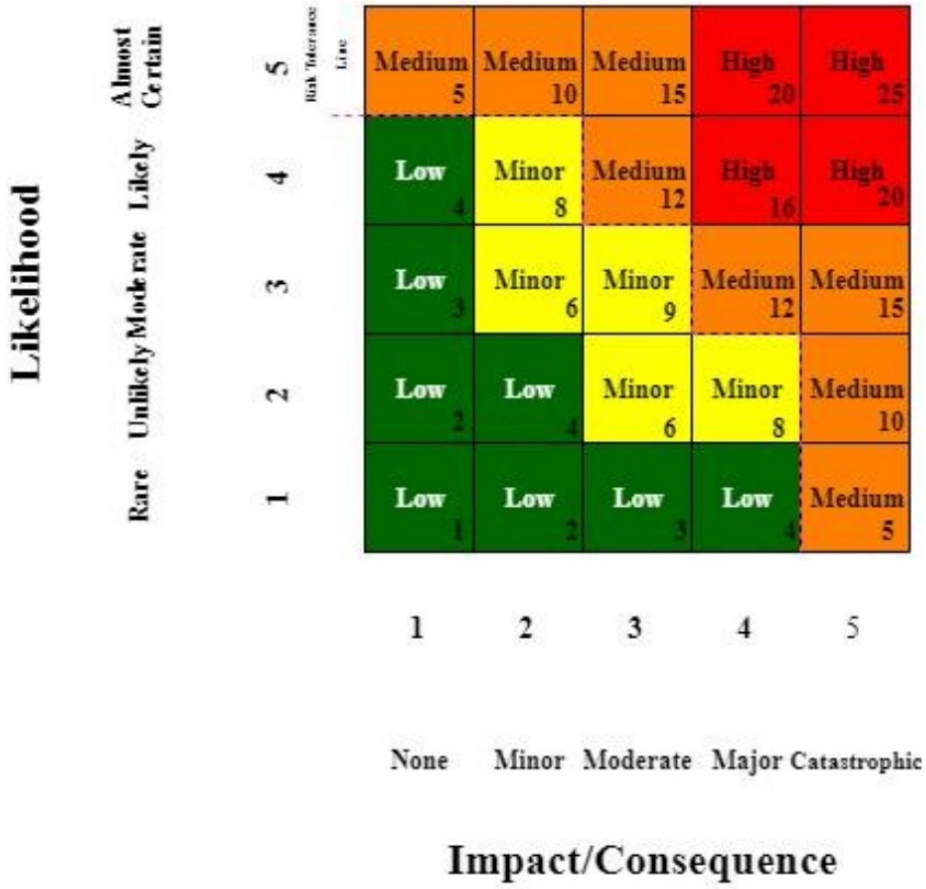

Figure 5. 3 Risk Map or Risk Matrix

After know the position risk in risk map or risk matrix the next step is risk treatment or risk response. Risk response is action taken to reduce risk (impact or likelihood) to the level of residuals that can be received, according to the company's risk tolerance. In risk response have four strategy to treat the risk is accept, share, reduce, and avoid. In evaluation choosing risk

response consider by the amount of risk tolerance, effectivity, cost & benefit, adequacy of resources and the minimum risk impact.

5.6 Risk Monitoring and Controlling

Risk monitoring and control is the final step from risk management. After the company have strategy to response or treatment the risk so company used the data to make risk management design. This monitoring step have some activity should be doing, in below will explain some activity in monitoring.

- Routine monitoring the actual performance of application risk management to its original plan or strategy.
- Ensuring effective risk management or mitigation.
- Identify new risks that arise.
- Focus on high and critical risks, monitoring the realization of the action plan is carried out more often than the low risks.
- For low risks must be monitored to ensure they remain in a low category and no surprising changes occur.

To facilitate monitoring that to make monitoring work sheet as a document can simply the monitoring and controlling activity. In monitoring work sheet must be some data used like risk event, mitigation plan, mitigation implementation time and realization time of mitigation. This document must be filled routinely and always monitoring to reduce the risk. This document also can used to controlling data because in document consist of data can use in controlling. Besides monitoring work sheet document in this step have one document also, the document call RACI matrix document. RACI matrix is document describes the participation by various roles in completing tasks or deliverables for a business process. RACI is an acronym derived

from the four key responsibilities most typically used: responsible, accountable, consulted, and informed. RACI used for clarifying and defining roles and responsibilities in cross-function or departmental project and processes.

5.7 Maintenance Management System

In this step will be explain the correlation risk management and maintenance. In maintenance management system all information and data from risk management process already explain in above used to make strategy in maintenance activity. The data from risk identification until risk monitoring and controlling used and will be a reference in maintenance activity. After risk monitor and control involves recording and communicating the relevant information on the status of risk control action plan for the identified risk factors. If any deviation occur, then corrective actions need to be evaluated by cycling the process back to evaluation phase. To minimize the deviation of risk so company must be create the strategy in maintenance to avoid the risk. Maintenance strategy consist of routine schedule for maintenance activity, handle the risk on maintenance activity, and improved the risk management plan if any risk occur.

The first explain the routine schedule for maintenance activity. Company should be created the routine schedule for monitoring and control the risk on maintenance activity. This activity have objective to monitor the risk so that there is not change the level of risk or new risks emerge. If any risks occur when maintenance activity so that the workers or maintenance workers already know the mitigation planning and prepare the tools or equipment to handle the risk. The maintenance activity not just handle the risks which the risks occur but after the risks occur maintenance already prepare the action or planning to make the production process run again. But if the high risk occur so the strategy in maintenance can helped to minimize the affect or loss of company with mitigation planning contained in maintenance strategy.

Maintenance activities also can improved the risk management plan if it's necessary to make more effective and efficiency the risk management plan or mitigation plan.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

This chapter describe the overall conclusion from the results of study and the suggestion for the future research.

6.1 Conclusion

The problem solving of problem formulation is already mention in chapters five above and based on the result will be conclude in this point.

A. The implementation of the SLR method resulted in 50 papers is the first distribution of journal consists of 38% or 19 papers related to hazard risk management, 22% or 11 papers related to maintenance, 20% or 10 papers related to risk assessment, 6% or 3 papers related to preventive maintenance & CMMs, and the last 4% or 2 papers related to ISO 31000 & SLR. Second, the publication years from 2014 & 2015 have the same amount that is 6 papers, for 2016 is 8 papers, 2017 with the amount of 6 papers, in 2018 have commonly amount that is 9 papers, 2019 have 8 papers, 2020 have 5 papers, and the last 2021 have 2 papers. Third, electronic database publication there are Elsevier with 84% or 42 papers, JSTOR 6% or 3 papers, IEEE and emerald insight 4% or 2 papers, the last Wiley with amount 2% or 1 paper. The last is the number of publication

for each publisher in this study have 29 classifications and the common amount is safety science with 8 papers.

B. The hazard risk management framework focus on maintenance has been improved in combining the 2 frameworks namely maintenance management and hazard risk management to create a more effective framework to use for the company. In this framework, researchers improve by including an application, namely CMM (Computerized Maintenance Management System) to facilitate the maintenance division to collaborate. In addition, this application can also provide decisions or orders in the event of a dangerous risk and cannot be avoided by issuing maintenance work orders. With a direct maintenance work order, the maintenance operator will be able to handle or repair it more quickly so that it can save maintenance time and also save costs that will be used for maintenance. For operators, it can also increase safety and minimize the risk of operator maintenance while doing tasks.

6.2 Recommendation

In order to make better knowledge and standard related the systematic literature review research, hazard risk management and maintenance, researcher give the recommendations, which are:

1) A company that will apply this framework should consider software CMMs (Computerized Maintenance Management system) carefully to minimize error; the standard data or variable should be carefully considered as they will be the basic of the framework.

2) This framework can be used as basic of the framework maintenance focused hazard risk management in its industrial process. Researcher strongly suggest implementing the framework if there has not been any framework applied to the company.

3) Further research can discuss more the scope of different factors for risk management such as financial risk management, operation risk management, enterprise risk management, and strategic risk management. Also, have a different treat to conduct the risk management.

4) It is also recommended to create comprehensive training for employees before applying the framework completely in the company. Hence, good coordination and proper skill of the employees in executing the framework can be achieved.

5) For future research, a more comprehensive framework that can specifically explain the scope of hazard risk management in risk management can be made through another SLR research. Moreover, relations between maintenance focused hazard risk management framework with other scopes of risk management framework can be observed or examined.

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