DESIGNING RISK MITIGATION IN SUPPLY CHAIN MANAGEMENT WITH SUPPLY CHAIN OPERATIONS REFERENCE (SCOR) APPROACH USING HOUSE OF RISK (HOR) METHOD
(CASE STUDY: PT. TAMURA AIR CONDITIONING INDONESIA)

UNDERGRADUATE THESIS

Submitted to International Undergraduate Program in Industrial Engineering in Partial Fulfillment of Requirement for the Degree of Sarjana Teknik at Faculty of Industrial Technology Universitas Islam Indonesia

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INTERNATIONAL UNDERGRADUATE PROGRAM IN INDUSTRIAL ENGINEERING

FACULTY OF INDUSTRIAL TECHNOLOGY

UNIVERSITAS ISLAM INDONESIA

YOGYAKARTA

2024

AUTHENTICITY STATEMENT

For the sake of Allah SWT, I respectfully acknowledge that this is my own work except for quotations and summaries which I have completely explained the source. If in the future it is proven that my confession is not true and violated the paper's legal guidelines and intellectual property rights, then I am willing to have my undergraduate certificate withdrawn by the Universitas Islam Indonesia.

Yogyakarta, 18 March 2024

(Nuraisyah Shafira Meilina)

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RESEARCH COMPLETION LETTER

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Atas perhatian dan kerjasamanya kami ucapkan terimakasih.

Hormat kami,
PT.Tamura Air Conditioning Indonesia

T.A.C.
PT. TAMURA AIR CONDITIONING INDONESIA

Ita Utami
HRGA

SUPERVISOR APPROVAL PAGE

DESIGNING RISK MITIGATION IN SUPPLY CHAIN MANAGEMENT WITH SUPPLY CHAIN OPERATIONS REFERENCE (SCOR) APPROACH USING HOUSE OF RISK (HOR) METHOD (CASE STUDY: PT. TAMURA AIR CONDITIONING INDONESIA)

UNDERGRADUATE THESIS

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EXAMINERS' APPROVAL PAGE

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Yogyakarta, 18 March 2024

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015220101

DEDICATION PAGE

Alhamdulillahirrabil'alamin
All of my gratitude and praise are to Allah SWT, by His grace I was able to successfully complete this undergraduate thesis.

I dedicate this special undergraduate thesis to myself, my beloved parents, and to Prof. Dr. Ir. Elisa Kusrini, M.T., CPIM, CSCP, SCOR-P., as a form of accountability for my studies to those who always provide encouragement, motivation, and countless prayers both morally and materially.

To my dearest friends who have helped me, encouraged me greatly, and motivated me countless times throughout my academic career.

MOTTO

"Stop overthinking. A piece of iron damaged by its own rust. Keep yourself from being harmed by your own thoughts. Don't worry too much; the greatest screenwriter has written your life's story."

Habib Umar bin Hafidz

"If we want to wait until we feel ready, we will spend the rest of our lives just waiting."

Lemony Snicket

"It is He who made the earth tame for you, so walk among its slopes and eat of His provision, and to Him is the resurrection."

Al-Mulk verse 15

PREFACE

Assalamu'alaikum Warahmatullahi Wabarakatuh

Alhamdulillahirabbil'alamin, praise and gratitude the author goes to the presence of Allah SWT who has given His mercy, grace, and guidance. *Shalawat* and greetings always to our lord Rasulullah Muhammad SAW as a role model for Muslims who keep us away from the era of ignorance.

With Allah SWT's permission, the author could complete the undergraduate thesis with the title of **"Designing Risk Mitigation in Supply Chain Risk Management with Supply Chain Operations Reference (SCOR) Approach Using House of Risk (HOR) Method (Case Study: PT Tamura Air Conditioning Indonesia)".** Therefore, the author would like to express gratitude to all parties involved in the making of this Undergraduate Thesis, namely:

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6. PT. Tamura Air Conditioning Indonesia which has allowed the author to carry out this undergraduate thesis research and has always assisted the author fully during the research.

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9. All of my friends from the Industrial Engineering batch 2019, my seniors, and juniors for the togetherness and support that cannot be mentioned individually.

The author is also aware that this undergraduate thesis still has some flaws. As a result, insightful criticism and recommendations are highly expected. The author hopes that readers or potential future researchers will benefit from this undergraduate thesis.

Wassalamu'alaikum Warahmatullahi Wabarakatuh.

Yogyakarta, 18 March 2024

(Nuraisyah Shafira Meilina)

ABSTRACT

The production process is closely linked to the performance of the manufacturing. Risks genuinely occur in the business process. The research was conducted at one of the metal goods companies that produce various types of components for air conditioners, located in Cikarang, Bekasi. It begins with the finished product that still fails every month. The production process that is undertaken has several stages with such equipment that has operational high risks. Thus, the aim of this research is to identify risks and design the most appropriate mitigation actions using the SCOR model approach and the House of Risk method to improve risk management performance and avoid production losses. Based on the proposed design framework that has been made, the risk identification process in the production department came up with 28 risk events and 18 risk agents in the process. By evaluation using the Pareto Diagram, two risk agents turns out to be the dominant risk which were then analyzed using the fishbone diagram. The results show that there are 7 priority mitigation strategies for the proposed risk mitigation design which are sought from two risks that fall into the high and significant categories.

Keywords: Risk Management, House of Risk, Mitigation Action, Secondary Risk, SCOR

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CHAPTER I
INTRODUCTION

1.1 Research Background

The success of business processes in a manufacturing industry is determined by various factors, including the continuity of production processes, product quality, cost efficiency, and high sales. Business process instability can occur due to various risks, including high operational risks on machines and equipment used in the production process. The production process is closely linked to the performance of the manufacturing industrial sector, and Indonesia's manufacturing sector significantly depends on effective and productive production processes to achieve sustainable growth. In fact, in recent years, the World Bank claimed that the Indonesian manufacturing industry has experienced significant growth. As a result, the manufacturing sector persists to be the main engine of the Indonesian economy. This is demonstrated by the industry that processes non-oil and gas, which consistently contributes the greatest percentage to the country's Gross Domestic Product (GDP)—achieving 16.30% in the second quarter of 2023—and makes the largest contribution to GDP as a whole. Agus Gumiwang Kartasasmita, the Minister of Industry, declared in August 2023 that the manufacturing sector had experienced the biggest growth in the country, with growth of 17.32% in the metal goods, computers, electronic goods, optics, and electrical equipment industries. (Kemenperin, 2023). Therefore, the manufacturing sector is becoming more and more competitive annually. With this increase in competition, industrial players and companies are trying hard to develop their businesses so that they do not experience a decline and can compete with existing companies. Managing the supply chain of the business effectively is one tactic that can be used by businesses to thrive in the marketplace (Wisnu, 2023).

PT. Tamura Air Conditioning Indonesia is a company that runs manufacturing in the field of air conditioning devices and services. The company specializes in the production, sale, and installation of any related air conditioning equipment. The main products sold are ducting, fitting, grille, flange, and many more. Founded in 1992, PT.

Tamura Air Conditioning Indonesia has a lot of experience and is considered one of the most credible companies and an expert in their field. However, a lot of accidents may occur unexpectedly since many processes occur in the production department at PT. Tamura Air Conditioning Indonesia, where the production process at each station consists of many machines and equipment with the potential for very high operational risks. The production process involves several stages and the machines used. Because the machines and equipment used have the potential for high operational risks, the company needs to ensure that the production process is carried out efficiently and ensures the quality of the products produced.

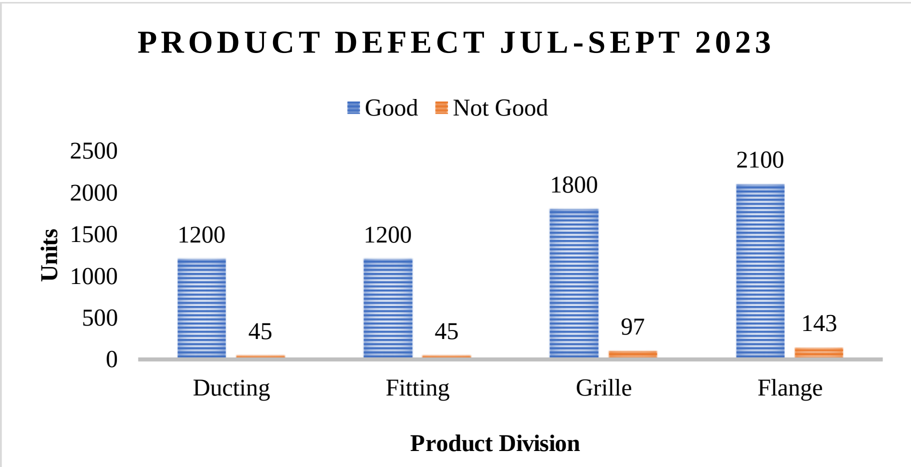

Figure 1.1. Product Defect

Source: TACI, 2023

PT. Tamura Air Conditioning Indonesia has been experiencing a string of manufacturing process failures, resulting in a significant decrease in output. According to the data presented in Figure 1.1 above, the production results from July to September 2023 indicate that some products still experiencing failures. Among the four production divisions currently in operation, the flange division showed the highest number of product failures when compared to the ducting, fitting, and grille divisions throughout a three-month timeframe. The situation can be ascribed to several factors, including product size that did not meet the requirements, programming errors, machine and cutting errors, scratches on the material, bad welding, missing paint process, bending errors, and even malfunction. This contributes resulting in defective products that do not meet required standards. It can be concluded that many problems that occur affect the end result of a product and cause the product to fail. A comprehensive examination of these aspects is necessary to have a complete understanding and provide a detailed explanation of the causes behind production failures. However, PT. Tamura Air Conditioning Indonesia has tried to implement some of the risk management elements by making risk management such as controlling, assessing, and identifying problems. Although in implementing those elements, the company still cannot optimize the method effectively.

In 2022, Nunes added that risks are typically correlated with their effects on project scope, quality, schedule, price, and resources. Risk management has traditionally been utilized to mitigate product problems, which go beyond product defects, to ensure customer safety and satisfaction. In the current industrial perspective, risk management is crucial not only for addressing product defects, but also for encompassing the entire production process. This includes managing risks associated with various aspects such as raw material acquisition and product distribution. Given the dynamic regulatory framework, globalization, and complex supply chains, a major change in approach is necessary to successfully address different types of risks, including event risks. These event risks are related to potential occurrences that have not yet happened, but if it does, they can significantly impact project objectives. Therefore, proactive actions are essential to maintain quality, reputation, and sustainability. This study will analyze the justification for implementing risk management comprehensively into production processes, emphasizing the advantages and consequences. Hence, existing manufacturers must consider risk management as a fundamental element of their entire production process in order to minimize risk, enhance resilience, and sustain a competitive edge. The focus on risk management is considered as a more strategic approach compared to only addressing product defects, as it includes wider and more profound elements related to operational effectiveness and product safety in the face of manufacturing failures.

To identify the activities that lead to production failures, starting from the acquisition of raw materials and moving forward through the value addition process that converts those materials into finished goods, up until the delivery of the resulting products to customers, one effective approach is to utilize the Supply Chain Operations Reference (SCOR) framework. This framework enables the measurement of supply chain performance and the identification of areas that require improvement to improve production efficiency and effectiveness (Muttaqin et al., 2022). Also, in order to minimize the risk and achieve its business objectives, this company needs to overcome any situation that may interfere with the process that runs through effective risk management strategies. Effective risk management is crucial in preventing project failure to identify and mitigate potential risks before they can cause failure (Goh and Ng, 2018). This failure could be prevented by implementing some methods such as a risk management system, risk assessment, and risk mitigation. The company can be one step forward before any risks interrupt the company's stability. Therefore, it is necessary to carry out a more in-depth analysis of the existing risks, especially in the production process to minimize losses for the company and produce products that meet the specifications and needs of consumers with the application of the House of Risk (HOR) method to help design the risk mitigation strategies that are most suitable to be implemented. In the case of PT. Tamura Air Conditioning Indonesia, the HOR method could identify relevant problems and plan an approach that included risk assessment, monitoring, and mitigation. These steps can help to reduce the likelihood of failure occurrence in PT. Tamura Air Conditioning Indonesia.

1.2 Problem Formulation

The following is the formulation of the problem that will be solved in this research:

1. What risk events that can affect the quality of finished goods in the production process of PT. Tamura Air Conditioning Indonesia?
2. What kind of the most appropriate mitigation strategy design to be applied in the production process of PT. Tamura Air Conditioning Indonesia based on the priority risks that occur?

1.3 Research Objective

The following are the objectives of this research:

1. To identify the risk events and risk agents that can affect the quality of finished goods in the production process of PT. Tamura Air Conditioning Indonesia.
2. To design the most appropriate risk mitigation strategies to be applied in the production process of PT. Tamura Air Conditioning Indonesia based on the priority risks that occur.

1.4 Scope of Research

The following are the limitations of the problem given:

1. This research was conducted on the production process at PT. Tamura Air Conditioning Indonesia, South Cikarang District, Bekasi Regency, West Java Indonesia.
2. The data obtained and used only concerns the supply chain operational activities in the production process at PT. Tamura Air Conditioning Indonesia.
3. The data used and analyzed are the results of interviews. questionnaires and focus group discussions carried out from July to September 2023.

1.5 Research Benefit

The following are the benefits expected from this research:

1. For companies, they could use the result of this research as a consideration of system change in the field of risk management. The company can also know what risks that may occur in the company.
2. For researchers, it is hoped that they can increase their knowledge and creativity about supply chain management, especially concerning risk management that can affect the result of production.

1.6 Systematic Writing

Systematics writing is a systematic approach to scientific writing that can enhance the structure and clarity of an undergraduate thesis report. The field of research systematics encompasses six primary areas of study. The following is the systematic writing that includes six chapters.

CHAPTER I INTRODUCTION

This chapter contains the background for the undergraduate thesis, the problem formulation, research objectives, the scope of the research, the benefits of the research, and systematic writing.

CHAPTER II LITERATURE REVIEW

This chapter contains an inductive study which discusses previous research related to this research and can be used as reference. There is a deductive study which can be used as a parameter in solving the problems in this research.

CHAPTER III METHODOLOGY

This chapter contains the research methods that will be used, the objects that will be studied, and the data collection methods needed during research. The flow of research framework is also explained in detail from beginning to end so that readers can easily understand.

CHAPTER IV DATA COLLECTION AND PROCESSING

This chapter discusses the data obtained during research to be processed further using predetermined methods. The results obtained from the processed data will be analyzed in the next chapter.

CHAPTER V DISCUSSION

This chapter contains research analysis from the results of data that has been processed using theoretical explanations and statistically based on the research findings and studies. This research analysis answers the problem formulation of the research conducted and helps in providing recommendations or suggestions on how to improve the supply chain of the air conditioning devices and service company.

CHAPTER VI CONCLUSION AND SUGGESTION

This chapter is the closing chapter which contains conclusions and suggestions regarding the thesis. The conclusion contains a brief summary of the results and discussion of the research that has been analyzed. Suggestions contain the author's ideas for further development of similar research to make it even better.

CHAPTER II
LITERATURE REVIEW

2.1 Inductive Study

Inductive study is an approach or method in research or analysis that focuses on collecting specific data or observations first, then identifying general patterns or trends from that data. In an inductive study, the researcher does not start with a fixed hypothesis, but rather collects data first and then draws conclusions or generalizations based on the patterns found. The inductive study also contains previous research related to the topic of this research. The limit of research references in this inductive study is research conducted in the past five years. The inductive studies in this research are as follows.

Previous research has been conducted by (Tarigan et al., 2022) with the title "Development of Quality Risk Mitigation Plan with Supply Chain Operation Model Approach Reference (SCOR) to Improve Crude Palm Oil Product Quality in PT. Citra Sawit Indah Lestari". The aim of this research is to analyze risk events and risk agents in the supply chain management process from palm oil fruit to Crude Palm Oil (CPO) and develop a Quality Risk Mitigation development plan to maintain the quality of Crude Palm Oil (CPO). This research is included in quantitative research which uses the House of Risk (HOR) method and the Supply Chain Operation Reference (SCOR) approach as a mapping tool. The results of this research show that 10 risk agents influence 80% of the poor quality of CPO so special action is needed to resolve this problem by focusing on those 10 risks. Another research with the same case was conducted by (Rohimmah et al, 2022) with the title "Risk Analysis and Risk Mitigation Strategy for Supply Chain Crude Palm Oil (CPO) Products (Case Study of PT. XYZ)". This research aims to identify supply chain risks in Crude Palm Oil (CPO) products. The difference is in the method, this research used the SCOR method as a risk mapping tool. The process begins with risk calculations using the Fuzzy FMEA method, and then the results of Severity (S), Occurrence (O), and Detection (D) are retrieved using the AHP method to determine the highest risk mitigation management strategy. The research results show that the plan activity is the activity with the highest risk, then the handling strategy used is optimizing machines and equipment. In addition, AHP was also used in research conducted by (Wahyukaton & FV, 2021) with the title "Risk analysis on crucial sector priority using Analytical Hierarchy Process (AHP) and House of Risk (HOR)". This research aims to identify risk events and risk agents at PT. PINDAD, especially in the Financial, Operational, and Strategy sectors. The methods used are the Analytical Hierarchy Process (AHP) and House of Risk (HOR). AHP is used to determine criteria weights and select risk agents, while HOR is used to determine Risk Mitigation. The results of this research show that the increase in Cost of Goods Production (HPP) is the cause of the selected risk with a weight of 0.132, then Financial Risk is determined as the main focus for determining risk mitigation. Based on the HOR, the risk mitigation implemented is monitoring and synchronizing the entire production schedule so that it matches the actual production floor.

In terms of supply chain management, research conducted by (Handayani & Rabihah, 2022) with the title "Risk mitigation in supply chain management process: procurement using the house of risk method at PT. Pertamina EP Asset 4" analyzed and managed the risks of procurement of goods and services at PT. Pertamina EP Asset 4 using the House of Risk (HOR) method with the help of Ms. Excel and data obtained through questionnaires and interviews. The results of this research found that there were 33 risk events with 61 risk causes, then 10 risk causes were taken based on the ARP value. One of the risk mitigation strategies with the greatest level of difficulty is developing a system that is able to accommodate the required details. Also, previous research conducted by (Sutawijaya & Marlapa, 2019) with the title "Supply Chain Management: Analysis and Application Using Reference (SCOR) at PT. Indoturbine". that identified the implementation of supply chain management at PT. Indoturbine by measuring the company's supply chain performance. This research is included in quantitative research using a model, namely the Supply Chain Operation Reference (SCOR), a performance measurement tool. The research results show that the supply chain conditions at this company are less efficient because the POF and OFCT values are below the Advantage

Data Benchmark values where the POF and OFCT values for this company are 64,03% and 92 days and the ADB values are 71,8% and 90 days.

Research conducted by (Purnomo et al, 2021) entitled “Risk Mitigation Analysis in a Supply Chain of Coffee using House of Risk Method”. This research aims to identify risks and develop a risk management strategy for Ground Coffee supply chain activities at the Kahyangan Jember Regional Plantation Company (PDP). The method used in this research is the House of Risk method as a tool for identifying and preparing risk management strategies. The results of research on HOR 1 found 28 risk events with 33 risk agents and 15 priority risk agents were taken as considerations in preparing risk management strategies. In HOR 2, there were 8 treatment strategies that could be used to solve this problem, one of which was eradicating pests in the coffee bean storage warehouse regularly.

Research conducted by (Rizqi & Khairunisa, 2020) entitled “Implementation of Supply Chain Risk Management (SCRM) Using House of Risk (HOR): Case Study on Supply Chain of Craft Bag Industry”. This research aims to identify risks in the Ajeng Gallery supply chain process and develop strategies for handling these risks. The method used in this research is House of Risk (HOR), starting from HOR 1 to HOR 2 where risk agents or causes of risk in this research are identified using Risk Cause Analysis (RCA). The results obtained were 10 risk events with 9 risk agents where from these risks 4 priority risk management strategies were taken, one of which was by providing product quality that met standards, so customer satisfaction would increase. In a similar industry, research conducted by (Sumrit & Keeratibhubordee, 2023) with the title “An integrated SWARA-QFD under Fermatean fuzzy set approach to assess proactive risk mitigation strategies in recycling supply chains: A case study of plastic recycling industry”. This research aims to identify risks and develop proactive risk management strategies in the supply chain process of plastic recycling companies. The method used in this research is Stepwise Weight Assessment Ratio Analysis (SWARA) and Quality Function Deployment where SWARA is used to determine the weight of the Recycle Supply Chain (RSC) assessment criteria and QFD is used to translate Customer Requirements into Technical Characteristics values and analyze the relationship between risk factors and appropriate proactive risk mitigation strategies. The results of this study show that the proposed framework can help logistics and supply chain managers in the plastic recycling industry in making rational decisions to implement proactive risk mitigation strategies.

Research conducted by (Yustika & Tan, 2021) entitled “Risk mitigation of goods procurement process using interpretive structural modeling, MICMAC analysis and the house of risk methods”. The aim of this research is to identify risk events and risk agents that occur in the company’s supply chain procurement process as well as identify the relationship between risks and design handling strategies that can be used to reduce the emergence of risk agents. The methods used in this research are Interpretative Structural Modeling (ISM), MICMAC analysis, and House of Risk. ISM is used to map the relationship between risk events and risk agents, MICMAC analysis is an advanced method for ISM which is used to determine the value of the factors driving these risks, while HOR is used to determine the handling strategies that need to be implemented for these problems. The results showed that there were 12 risk events and 26 risk agents, of which 11 risk management strategies were obtained, one of which was changing the procurement process using e-procurement.

Research conducted by (Hadi et al., 2020) with the title “Identification of Supply Chain Risks using the House of Risk Method”. This research aims to identify the risks experienced in the supply chain management process at PT. XYZ. The method used in this research is the House of Risk method as a risk mitigation design tool and for finding risk priorities. Apart from that, the SCOR method is also used in this research to map SCM and FMEA activities to identify problems or risks that are faced. The results of this research found 5 risk events with 28 risk agents and one of the risk agents with the largest ARP value was the accumulation of goods for too long (A11). Recommendations offered include improving system information, evaluating performance with customers, conducting training for employees, improving technology on repair inspection machines and imposing sanctions on workers who work not according to SOPs. Research conducted by (Magdalena & Vannie, 2019) entitled “Supply Chain Risk Analysis Using the House of Risk (HOR) Model at PT. Tatalogam Lestari”. The aim of this research is to analyze risk events and risk agents in operational activities at Plant L8. This research uses the

House of Risk method as a tool for measuring the severity of risk events and risk agents, identifying risks by conducting interviews and observations in the factory environment which is analyzed using the FMEA method. The results of the research found 8 risk agents which were the cause of 80% of operational activity problems based on HOR 1. In HOR 2, preventive steps were identified, one of which was additional verification features and briefing on machine work procedures every work rotation.

Research conducted by (Rozudin & Mahbubah, 2021) with the title Implementation of the House of Risk Method in Green Supply Chain Risk Management for Bogie S2HD9C Products (Case Study: PT. Barata Indonesia). The aim of this research is to identify supply chain risks and develop a risk management strategy at PT. Barata Indonesia, especially for the Bogie S2HD9C product. The research methods used are the House of Risk method and Green Supply Chain Operation Reference (GSCOR) for activity mapping. The research results found 82 risk events with 22 risk agents and 22 actions to deal with these problems. In HOR 1, there were 10 priority risk agents out of 22 risk agents, and in HOR there were 5 risk mitigation strategy actions, one of which was implementing human resource development. Moreover, Baştuğ et al. (2023) in “Risk mitigation in service industries: A research agenda on container shipping” identify the causes of risk and develop risk management strategies in the context of marketing risk on shipping lines. The method used in this research is a literature review and Spherical Fuzzy Theory. The results of this research show that the cause of this risk is due to unexpected things, for example, natural disasters; war; tsunami; or COVID-19.

Research conducted by (Pertiwi et al., 2022) with the title “Operational Supply Chain Risk Management on Apparel Industry Based on Supply Chain Operation Reference (SCOR)”. The aim of this research is to identify possible risks that will occur in business processes, procedures, logistics, and consumers and to develop a strategic plan for handling these risks. The research method used is SCOR for mapping supply chain activities and the House of Risk method for determining risk management strategies. The research results found 25 risk events with 23 risk agents, and then 39 relationships were found between risk events and risk agents, of which 39 relationships contained 22 high-scale relationships. Jung et al. (2019) stated that risk assessment can be used to prevent the occurrence of potential risks by enhancing the efficacy of decision-making regarding the execution and implementation of risk reduction measures. Risk assessment is an integral component of risk management, which is the most critical effort that must be accomplished (Chaouch et al., 2019).

2.2 Deductive Study

2.2.1 Supply Chain Management

The Supply-Chain Council defines Supply Chain Management (SCM) as the comprehensive process of manufacturing and distributing a finished product, starting from the supplier's supplier and ending with the customer's customer (Larson & Rogers, 1998). A supply chain is a complex network that consists of multiple businesses or organizations that are involved in the production, service, and distribution of finished products to end customers or retail outlets. This network is comprised of a number of different businesses or organizations, each of which plays a particular role. These businesses and organizations include suppliers, manufacturers, distributors, retailers, and customers. It is a discipline known as supply chain management that is responsible for coordinating the flow of information, resources, and finances from the beginning of a production process all the way through to its completion. It is because of this that the production and distribution of goods or services are carried out in the appropriate quantities, in the appropriate locations, and at the appropriate times (Sriwana et al., 2021).

2.2.2 Supply Chain Operation Reference (SCOR) Model

The Supply Chain Operations Reference (SCOR) is a framework used to assess and determine the condition and effectiveness of the supply chain. This can be accomplished by segmenting the SCOR structure into five basic activities. While SCOR does not have a direct impact on production success, it serves as a valuable tool for organizations to assess supply chain performance and identify areas that require improvement to improve production efficiency and effectiveness. Furthermore, the application of the SCOR approach helps organizations assess supply chain performance by identifying the most crucial performance indicators and attributes that hold the greatest significance and value for the company's supply chain (Sriwana et al., 2021).

The mapping of the supply chain is facilitated by five basic processes, as identified by the Supply Chain Council (2012): plan, source, make, deliver, and return. The following are descriptions of the five basic processes:

a. Plan

   It involves the analysis of information and the prediction of market trends for goods and services. Both finance and marketing departments use a planning strategy through the application of monthly and annual reports.

b. Source

   This is a procurement system that uses a procurement model. The system combines search, negotiation, and evaluation agents to enhance the process of selecting, negotiating with, and evaluating suppliers.

c. Make

   It refers to the production of items, taking into account both the time required and the organization of the production process, including the assembly process and the production stages.

d. Deliver

   This procedure involves delivering completed products and services to meet the intended or actual demand.

e. Return

   It involves the act of returning the products and receiving the product. The situation could occur if the products fail to align with the specific requirements and demands.

2.2.3 Risk

According to AS/NZS (2004), risk is the possibility of an event occurring that has a positive or negative impact on achieving a certain goal. Risk can be described as the likelihood of an unwanted occurrence happening, which may result in negative consequences for people, systems, or assets. ISO 31000 defines risk as the impact of uncertainty on organizational goals. Therefore, it is necessary to effectively and efficiently manage and optimize risks in order to achieve the desired outcomes of the organization (Hanafi, 2014).

According to Lokobal et al. (2014), the following are the four sources that contribute to the emergence of risk:

1. Internal risk refers to the potential risks that come from within the organization.
2. External risk refers to the potential risks that come from sources external to the company.
3. Financial risk refers to the potential for loss or negative impact resulting from fluctuations in currency values and pricing levels.
4. Operational Risk refers to the potential risks that result from human activities, environmental conditions, and the utilization of tools.

2.2.4 Risk Management

Previous research conducted by Mohanty & Panda in 2020 defines risk management as the systematic and continuous process of identifying, assessing, mitigating, and monitoring risks associated with the adoption and the use of Industry 4.0 technologies. The process involves evaluating potential risks, developing strategies to control them, and implementing actions to minimize the probability or consequences of undesirable incidents by allocating resources or delegating authority. Risk management is important and is good if implemented correctly and effectively by a company. Risk management can detect any risk that may occur in a company and the company can prevent it long before the unwanted risks happen. In order to achieve business objectives, a company needs to overcome any situation that may interfere with the process that runs. Within the field of risk management, there are five different steps involved in supply chain risk management. These steps include the identification of risks, the evaluation of risks, the mapping of risks, the design and implementation of alternative risk management strategies, and the continual evaluation and control of risk management strategies (Pertiwi et al., 2022).

According to (Lokobal et al., 2014), risk management has several processes that must be passed, including:

1. Risk Management Planning

   During this process, it is necessary to follow an order of processes to effectively design risk management actions for the project.

2. Risk Identification

   During this process, business organizations must acknowledge the various categories of potential risks that each business actor might experience.

3. Qualitative Risk Analysis

   Qualitative analysis can be used in this process to evaluate the effects and potential risks that have been previously discovered. This evaluation is conducted by organizing risks according to their impact on project objectives. In measuring qualitative analysis, the scale used is the Australian Standard/New Zealand Standard (AS/NZS 4360:2004). Here is the scale of measurement:

   A: Highly possible and unavoidable in all circumstances (≤2 times/ 3 months)

   B: Probably to occur in all circumstances (3-5 times/ 3 months)

   C: It ought to occur consistently (6-8 times/ 3 months)

   D: It tends to happen at one time (8-10 times / 3 months)

   E: Rarely happen (>10 times/ 3 months)

   The scale used to measure consequence analysis, according to NA/NZS 4360:2004, is as follows:

   Insignificant : No substantial loss

   Minor : Moderate loss of substance

   Moderate : The extent of material losses is significant.

   Significant : Substantial material damages

   Catastrophic : Extreme loss

4. Quantitative Risk Analysis

   This technique involves quantitatively identifying the probability of each risk and assessing its impact on the project objectives.

5. Risk Response Planning

During this process, the level of risk encountered is reduced to an acceptable level. This level of risk can be determined by considering the risk appetite. Ripley (Ripley, 2021) mentioned that many organizations have adopted the idea of risk appetite, which is actively considered in decision-making. In this research, risk appetite refers to the amount of risk that a company will tolerate regardless of whether it is willing to operate at that level of risk. Risk appetite is the basis for determining risk tolerance, namely the quantitative limits of the level of possibility and level of risk impact that can be accepted, as stated in the risk criteria (Rahayu et al., 2023).

Table 2.1. Risk Rating According to AS/NZS 4360:2004

Likelihood of Consequences	**Potential Consequences**				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	1	**2**	**3**	**4**	**5**
A (Almost Certain)	S	S	H	H	H
B (Likely)	M	S	S	H	H
C (Moderate)	L	M	S	H	H
D (Unlikely)	L	L	M	S	H
E (Rare)	L	L	M	S	S

Source: Risk Management Guidelines Companion to AS/NZS 4360:2004.

Table 2.1 shows a risk level matrix based on AS/NZS4360:2004. The risk level matrix above contains various risk level categories symbolized by different colors and letter initials in each column. In this research, risks at the low and medium levels are risks that are in the risk acceptance area and do not need to be mitigated. Risks at significant and high levels are priority risks that must be mitigated to avoid losses in production (Rahayu et al., 2023). A detailed explanation of each initial letter and color can be seen below.

Table 2.2. Risk Level Category

Risk Level	Description	Action
H (High Risk)	Unacceptable, should be eliminated or transferred	Take immediate action
S (Significant Risk)	Undesirable, should be avoided	Need immediate corrective action
M (Medium Risk)	Acceptable	Perform corrective actions on a regular and timely basis
Low (Low Risk)	Negligible	No action needed

6. Risk Control and Monitoring

   This process involves the monitoring of observed risks, followed by the monitoring of remaining risks. Additionally, new risks will be discovered and the implementation of the risk management plan will be ensured. The effectiveness of the strategy in decreasing risk will also be evaluated.

2.2.5 House of Risk (HOR)

According to Molenaar & Song (2019), the House of Risk (HOR) method was effective at identifying and mitigating risks in construction projects. The study emphasized the importance of using the HOR method to ensure all potential risks are identified. Pujawan & Geraldin (2009) define the HOR as a methodology that specifically addresses the identification and implementation of preventive, reduction, and management methods for multiple risk factors. This method integrates two distinct models, specifically Failure Mode and Effect Analysis (FMEA) for risk level analysis, and House of Quality (HOQ) for strategy development. In contrast to existing models, this particular model distinguishes itself by selecting a risk agent in the HOR who possesses a high Aggregate Risk Potentials (ARP). This indicates that the risk agent is more likely to trigger several risk events with significant repercussions. The mitigation strategies for selected risk agents are determined by considering the overall effectiveness ratio for the level of difficulty and the ability of these actions to lower a substantial number of risk agents with high ARP values. In order to assess the priority of risk agents for future action, it has to be done to calculate the ARP value. The formula for calculating ARP is as follows:

$$ARP_j = O_j \sum S_i R_{ij} \dots \quad (2.1)$$

Where:

ARP_j : Aggregate Risk Potential

O_j : Possibility of occurrence of risk agent

S_i : Severity of influence of risk event

R_{ij} : Correlation between risk agent and risk event

The HOR model handles risks in two stages. The first is HOR phase 1. HOR phase 1 will identify risks first, followed by HOR phase 2. Risks identified in HOR phase 2 will be addressed by taking appropriate precautions.

a. HOR Phase 1

This phase is carried out to determine risk agents that must be prioritized for preventive action. The stages carried out in the HOR phase 1 model include:

1. Identify risk events that occur in supply chain mapping such as plan, source, make, deliver, and return.
2. Provide an assessment to find out how big the impact or severity (S) is and the probability of a risk agent if the risk occurs. There are five severity categories: none, minor, moderate, severe, and extreme with the rating scale used is 1-5. The criteria are determined based on the company's policies and standards. The following is the listed rating scale of severity.

Table 2.3. Severity Scale

Ranking	Severity	Description	Criteria		
			Success Level	Product Quality	Financial Loss
1	Insignificant	No effect	Project success by 96%-100%	Defects by < 1% of total production	Loss < 5% of revenue
2	Minor	The risk of causing minor disruption	Project success by 91%-95%	Defects by 1-10% of total production	Loss of 5-10% of revenue
3	Moderate	Moderate risk of causing disruption	Project success by 86%-90%	Defects by 11-20% of total production	Loss of 11-15% of revenue
4	Major	The risk of causing very severe disruption	Project success by 81%-85%	Defects by 21-30% of total production	Loss of 16-20% of revenue
5	Catastrophic	The risk of causing extreme disruption	Project success by ≤ 80%	Defects by > 30% of total production	Loss of > 20% of revenue

3. Identify risk sources and provide an assessment of the possibility of each risk source using a scale of 1-5. There are five occurrence categories as stated above. The criteria are determined according to AS/NZS 4360:2004 and depend on the probability of risk that happens in 3 months. The following is the listed rating scale of occurrence.

Table 2.4. Occurrence Scale

Ranking	Occurrence	Description	Criteria
1	Rare	The occurrence of risk causes is almost non-existent	≤2 times/ 3 months
2	Unlikely	The occurrence of risk causes is low	3-5 times/ 3 months
3	Moderate	The occurrence of risk causes is moderate	6-8 times/ 3 months
4	Likely	The occurrence of risk causes is high	8-10 times/ 3 months
5	Almost certain	The occurrence of a risk cause has almost always happened	>10 times/ 3 months

4. Determine the correlation between risk agent and risk event using a scale of 0, 1, 3, 9. A scale of 0 indicates no correlation, the scale of 1 indicates low correlation, a scale of 3 indicates a moderate correlation and scale 9 indicates high correlation.
5. Calculating the ARP value to determine priority risk agents for further action. The ARP calculation formula that is used is as shown in Formula 2.1.
6. Make a sequence of ARP values from the largest value to the lowest value.

Table 2.5. House of Risk Phase 1 Model

Business Processes	Risk Event (E_i)	Risk Agent (Aj)							Severity of Risk Event i (Si)
		A_1	A_2	A_3	A_4	A_5	A_6	A_7	
Plan	E1	R_{11}	R_{12}	R_{13}					S1
	E2	R_{21}	R_{22}						S2
Source	E3	R_{31}							S3
	E4	R_{41}							S4
Make	E5								S5
	E6								S6
Deliver	E7								S7
	E8								S8
Return	E9								S9
Occurrence of Agent *j*		O_1	O_2	O_3	O_4	O_5	O_6	O_7	
Aggregate Risk Potential *j*		ARP_1	ARP_2	ARP_3	ARP_4	ARP_5	ARP_6	ARP_7	
Priority Rank of Agent *j*									

b. HOR Phase 2

This phase is carried out to determine the priority of the first action by considering the effectiveness of these actions. It can be seen from the side of the resources or finances owned. The stages carried out in the HOR phase 2 model include:

1. Perform a selection of risk agents in the highest positions using Pareto chart analysis.
2. Identify suitable actions to minimize risk agents or causes of risk. One cause of risk can be minimized by more than one action.
3. Determine the correlation of each precautionary measure and source of risk using a scale of 0, 1, 3, 9. A scale of 0 indicates no correlation and a scale of 1, 3, 9 respectively shows correlation, low, medium and high.
4. Perform calculations on the amount of effectiveness using the formula:

$$TE_k = \sum ARP_j \cdot E_{jk} \ldots \quad (2.2)$$

Where:

TE_k : Total effectiveness of each action

ARPj : Aggregate Risk Potential

E_{jk} : Correlation between each preventive action and each risk agent.

5. Calculate the level of difficulty (Dk) in implementing each action using a scale of 3, 4, 5. Scale 3 indicates the action is easy to implement, scale 4 indicates the action is rather difficult to implement, and scale 5 indicates the action is difficult to implement.
6. Calculating the total effectiveness ratio for each mitigation action that will be carried out.

$$ETD_k = TE_k / D_k \ldots \quad (2.3)$$

Where:

ETD_k : Total effectiveness of the difficulty level

TE_k : Total effectiveness

D_k : Difficulty level

7. Sort each action by ETD_k value from highest to lowest.

Table 2.6. House of Risk Phase 2 Model

To be treated risk agent (A_j)	**Risk Mitigation (M_k)**					**Aggregate Risk Potential (ARP_j)**
	M_1	**M_2**	**M_3**	**M_4**	**M_5**	
A1	E_{11}	E_{12}	E_{13}			**ARP_1**
A2	E_{21}	E_{22}				**ARP_2**
A3	E_{31}					**ARP_3**
A4	E_{41}					**ARP_4**
Total Effectiveness of Action *k*	TE_1	TE_2	TE_3	TE_4	TE_5	
Degree of Difficulty Performing Action *k*	D_1	D_2	D_3	D_4	D_5	
Effectiveness to Difficulty Ratio	ETD_1	ETD_2	ETD_3	ETD_4	ETD_5	
Rank of Priority	R_1	R_2	R_3	R_4	R_5	

2.2.6 Expert Judgement

Meyer & Booker (2001) defined expert judgment as a technique that includes gathering information based on the opinions of experts on a given situation. Expert Judgment is a method in which an evaluation is made using specific criteria and/or specialized expertise obtained in a specific scientific, application, or product area, as well as in certain scientific disciplines, industries, etc. Expert Judgment is used in situations requiring the effective application of specialized knowledge and expertise. This includes tasks such as analyzing, verifying, interpreting, and consolidating available data, evaluating the effects of change, forecasting future events and decision outcomes, assessing the current level of knowledge in a particular field, and providing essential elements for decision-making when multiple options are present (Sotille, 2019). According to Hora (2009), an expert itself is defined as an individual who possesses the knowledge and expertise to effectively solve problems within their specific sector. Hora suggests that in order to obtain a comprehensive understanding, it is necessary to gather approximately 3 to 7 expert viewpoints through a systematic study.

2.2.7 Pareto Diagram

The Pareto diagram is an incredibly effective tool for illustrating the significance of a problem. Vilfredo Pareto, an Italian economist and sociologist, initially applied this theory after discovering that 20% of the people in Italy owned a majority of 80% of the land. The Pareto principle, or the 80/20 rule, is a versatile concept that has applications in various domains such as economics, sociology, and quality management (Sanders, 1987). Approximately 80% of the negative effects may be attributed to a mere 20% of the causes. The visual representation consists of bars and lines, with the bars indicating individual values arranged in descending order, and the curved lines indicating the cumulative sum of samples. The existence of the 80% cutoff line serves to indicate the application of the 80/20 rule, wherein certain important factors that demand the greatest care fall below the 80% cutoff line.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Research Subject and Object Design

The subject of the research is PT. Tamura Air Conditioning Indonesia, located at Jalan Akasia 1 Blok A8 No.3, Delta Silicon Industrial Area 1, South Cikarang District, Bekasi Regency, West Java, Indonesia. The object of this research is risk management in supply chain management, specifically examining risk activities in the production processes. Moreover, the evaluation of these objects requires the expertise of a person who has a deep understanding of PT. Tamura Air Conditioning Indonesia's supply chain activities.

3.2 Data Collection Method

The following statements are the two types of data used in this research.

1. Primary Data

   Smith (2020) defines primary data as data that is gathered subjectively by the researcher through methods such as surveys, interviews, and experiments. This type of data is distinct from information that has been previously published or acquired by others. The key data for this research were collected through interviews conducted with the Assistant Manager of the Production Department, the Purchasing Staff of the Production Department, and the Secretary of the Personnel & GA Department. The interview was undertaken to directly gather data on the identification of risk events and risk agents related to production failures.

2. Secondary Data

   Secondary data refers to information that is collected from existing sources. This data is utilized to fulfill the information and data requirements specified by researchers. The research relied on academic journals, related articles, and existing studies as its primary sources.

3.3 Research Flow

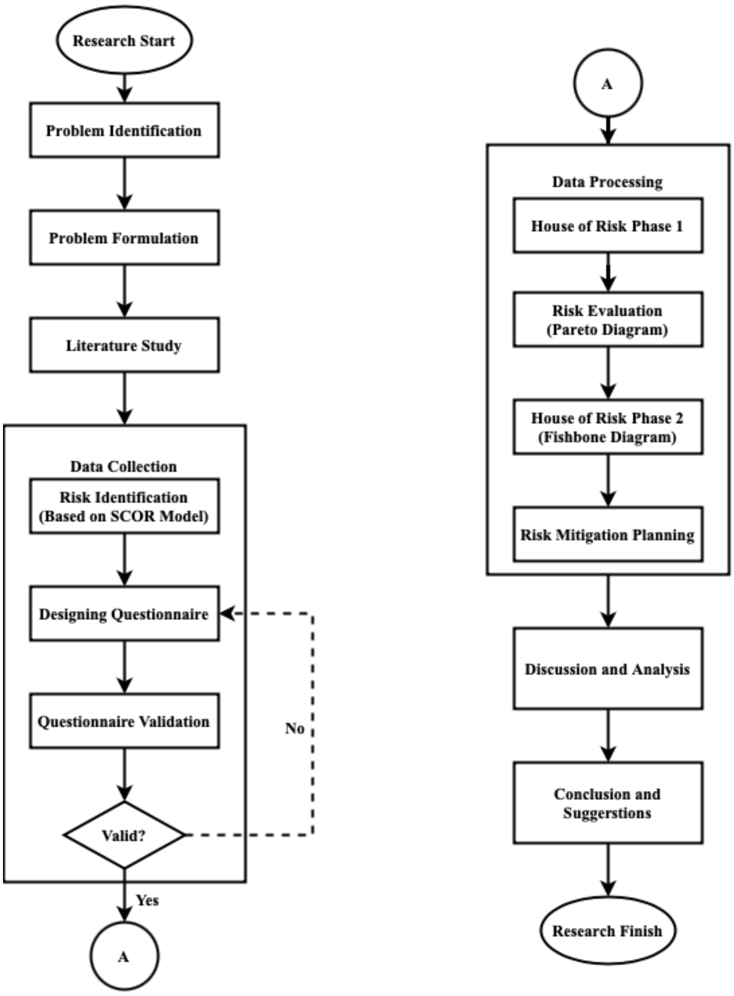

Figure 3.1. Research Flow

The following is an explanation of the research flow above

1. Problem Identification

   The initial step involves identifying issues within the inspection procedure of the production process industry. During this phase, the researcher first identifies the current issue and subsequently formulates a precise problem statement and research scope to be studied.

2. Literature study

   A literature study is a systematic examination conducted to look into methods for data processing. The literature review for this research endeavor will focus exclusively on the SCOR model approach, Risk Management, House of Risk, and Pareto Diagrams.

3. Data collection

   The data collection method used in this research encompasses observation, interviews, and questionnaires. Information was obtained through interviews with the secretary of the Personnel & GA department, the assistant manager, and the purchasing staff of the production department. This interview was done with the discussion to align the information gained from previous research with expert viewpoints.

4. Data Processing

   After obtaining the interview results, data processing is conducted, which includes risk analysis and evaluation as indicated below.

5. Discussion and Analysis

   The researcher performs an analysis using the computed data results and provides recommendations based on the discovered concerns for PT. Tamura Air Conditioning Indonesia.

6. Conclusions and suggestions

   After completing the preceding steps, decisions will be made based on the findings of the research analysis conducted to address the current problem formulation, establish, and provide recommendations to improve future risk management, specifically for PT. Tamura Air Conditioning Indonesia.

CHAPTER IV
DATA COLLECTION AND PROCESSING

4.1 Data Collection

4.1.1 Company Profile

PT. Tamura Air Conditioning Indonesia is a Japanese-Indonesian company engaged in manufacturing and was established on October 20th, 1992 in Jakarta. The establishment was officially documented through notary deed No. 12 dated October 20th, 1992, and was authorized by the Minister of Justice of the Republic of Indonesia under decree No. C2/8906.HT.01.0.1993. Subsequently, an amendment was made through the notary deed Elvina Maisyarah, S.H, M.H., No. 01, dated 1st August 2008, and was further approved by the Minister of Law and Human Rights under stipulation No. AHU-7 5744.AH.01.02.2008. The company's establishment has been published in the Supplement to the State Gazette of the Republic of Indonesia 23/9-2009 No. 23.

PT. Tamura Air Conditioning Indonesia specializes in the production, sale, and installation of air conditioning equipment and their accompanying accessories. PT. Tamura Air Conditioning Indonesia operates as a manufacturer of prefabricated metal products specifically designed for building installations. The primary items manufactured include ducting, fittings, spirals, flexibles, grilles, louvers, dampers, fire dampers, motorized dampers, check dampers, flanges, supports, hangers, and other air duct manufacturers. The following are the detailed research-focused items produced by PT. Tamura Air Conditioning Indonesia.

Table 4. 1. Product Description

No.	Product Division	Description
1.	Ducting	Item: Square duct, Round duct There are three types of material for producing Duct products, such as Galvanized steel (suitable for general air conditioning & ventilation ducts), Stainless steel (suitable for a duct that is used outdoors or distributes moisture, oil, and heat), and Galvalume Steel (suitable for a duct that used in outdoor or high humidity and rustic environment.
2.	Fitting	Item: Round duct, Elbow, Reducer This product used Galvanized steel because the spiral duct is a thin and light pipe duct made of Galvanized steel that is formed by joining both ends of the hoop while molded into a spiral shape with a thickness of around 0.5 mm ~ 1.0mm, and a width of 100mm ~ 150mm. The company offers an advanced spiral duct manufacturing machine and provides Socket weld and Flange connecting methods for standard pipes.

No.	Product Division	Description
3.	Grille	Item: Grille, Diffuser, Rain hood, Vent cap, Filter, Shutter (handle and gear) There are three types of material for Grille products such as aluminum, stainless steel (Face & Blade), and steel (Shutter).
3.	Flange/Damper	Item: Volume damper square, Volume damper round, Flange square, Flange round, Support (bracket and support angle). A damper automatically regulates the flow of air inside a duct and is divided into an air conditioning damper and a prevention damper.

4.1.2 Company Vision and Mission

The following statements are the vision and mission of PT. Tamura Air Conditioning Indonesia.

4.1.2.1 Vision

"To be the Best Air Conditioning Equipment Manufacturer in Indonesia".

4.1.2.2 Mission

1. Productivity Increase
   - Automation Technical Support
   - Management System
   - Computerization
   - Education
2. Technology Function Increase
   - Improvement in Product Performance
   - Design, Analysis, and Test
3. Sales Channels Development

4.1.3 Company Location

The geographical situation of Bekasi Regency includes agriculture, industry, trade, and services. Bekasi City is further subdivided into four development regions. The company is located in the southern Cikarang region, which is centrally positioned in the Bekasi Regency. This area is known for its industrial development, trade and services, housing and settlements, tourism, and supporting industrial operations. It spans an area of 5,174 hectares (BPS, 2019). The Bekasi Regency RT/RW 2011–2031, which outlines the Regional Development Plan, includes the following locations as part of its service areas:

South Tambun, Cibitung, North Cikarang, West Cikarang, East Cikarang, and South Cikarang.

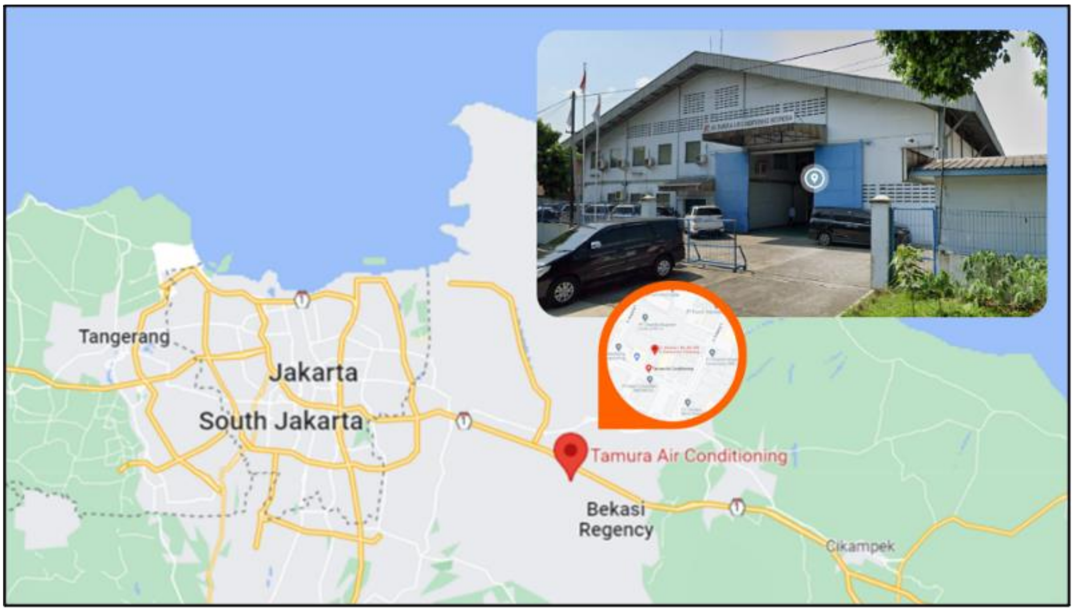

Figure 4.1. Company Location
Source: Google Maps, 2023

PT. Tamura Air Conditioning Indonesia is located in Jalan Akasia 1 Block A8 No.3, Delta Silicon Industrial Area 1, South Cikarang District, Bekasi Regency, West Java Indonesia. The company's buildings cover a land area of 4,625 m^2 and a building area of 2,925 m^2. This organization benefits from a strategic location that offers advantageous market positioning, access to raw materials, efficient logistics, well-equipped facilities, and substantial infrastructure. Situated among metropolitan areas, it also serves as a transit hub connecting to other urban centers.

4.1.4 Business Processes

The supply chain flow is a sequential process of steps or operations that involves multiple stages or activities. PT. Tamura Air Conditioning Indonesia has three different types of flows in its supply chain: the flow of information, the flow of items, and the flow of finance. Each flow has its direction. The following is the sequential flow of the supply chain of PT. Tamura Air Conditioning Indonesia:

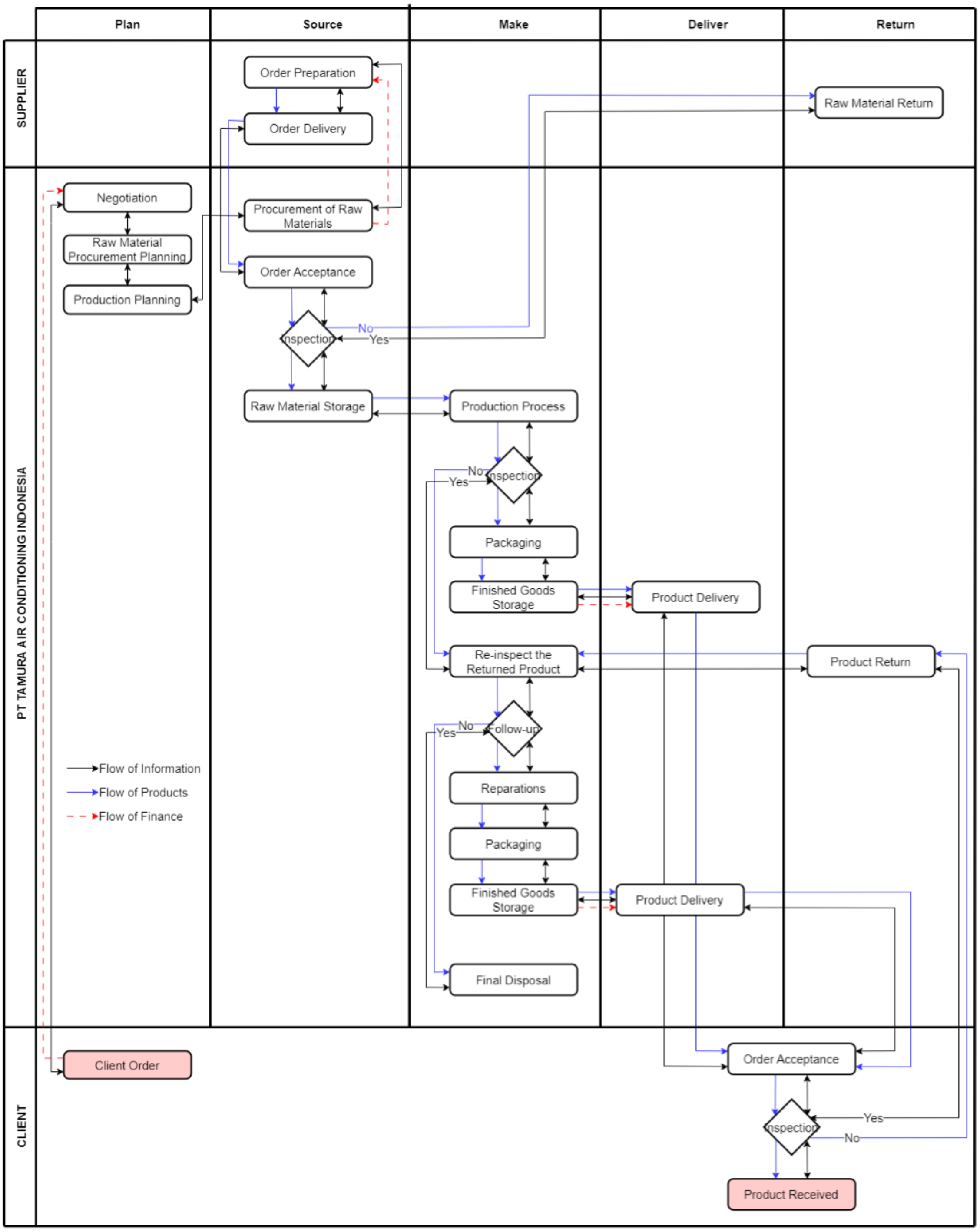

Figure 4.2. Supply Chain Activity Mapping Flow

Source: PT. TACI, 2023.

Figure 4.2 depicts the flow of the company's supply chain mapping. To do supply chain activity mapping based on the Supply Chain Operations Reference model, the flow can be divided into five business processes: plan, source, make, deliver, and return.

Mapping down each business process provides a comprehensive understanding of the flow of the supply chain at PT. Tamura Air Conditioning Indonesia. Here, the SCOR Model is used as the tool for identifying and mapping the business processes comprehensively. This simplifies the identification of risks that arise from each activity for further risk assessment process. PT. Tamura Air Conditioning Indonesia performs a total of 17 production activities. Table 4.2 illustrates the production activities of PT. Tamura Air Conditioning Indonesia in detail.

Table 4.2. Supply Chain Activity Mapping at PT. TACI

No.	SCOR		Activities	Code
	Business Processes	**Sub Processes**		
1.	Plan	Plan Supply Chain	Identify, prioritize and aggregate supply chain requirements	C1
			Balance supply chain resources with supply chain requirements	C2
			Establish and communicate supply chain plans	C3
		Plan Source	Balance product resources with product requirements	C4
			Establish sourcing plans	C5
		Plan Make	Balance production resources with production requirements	C6
			Creating production plans	C7
2.	Source	Make-to-Order Product	Receiving product deliveries from suppliers	C8
			Verify product	C9
3.	Make	Make-to-Order	Schedule production activities	C10
			Production and test	C11
			Release finished product to deliver	C12
4.	Deliver	Deliver Make-to-Order Product	Load product & generate shipping docs	C13
			Shipping product	C14
5.	Return	Source Return Defective Product	Identify defective product condition	C15
			Schedule defective product shipment	C16
		Return Defective Product	Transfer defective product	C17

4.1.5 Risk Identification

The assessment was conducted by interviewing the production department expert at PT. Tamura Air Conditioning Indonesia. Subsequently, a result assessment regarding the risk event was carried out using a questionnaire given to experts. The participants listed below provided their expertise in the research.

Table 4.3. Expert

Expert	Position	Age	Length of work
1	Assistant Manager	53	± 30 years
2	Assistant Manager	37	± 6 years
3	Purchasing Staff	33	± 5 years

Based on the questionnaire carried out by experts, the severity value of 28 risk events were obtained from 17 production activities that occurred at PT. Tamura Air Conditioning Indonesia. The following table shows the results of the interview and filling in the questionnaire regarding risk events.

Table 4.4. Risk Event Identification

Business Processes	**Code**	**Risk Event**	**Code**	**Severity**
Plan	C1	Errors in demand forecast calculations	E1	4
	C2	Unable to fulfill request	E2	3
	C3	Lack of information between the supply chain planner	E3	3
	C4	Overflow of customer requests at the same time	E4	5
	C5	Errors in planning the procurement of raw materials	E5	3
	C6	Unpreparedness of production facilities	E6	3
	C7	Errors in scheduling production plan	E7	3
Source	C8	Delay in arriving raw materials	E8	4
	C9	Insufficient quantity of incoming raw materials	E9	5
	C10	The quality of raw materials does not meet standards	E10	2
Make	C11	Production flow is less organized and look messy	E11	3
		Production delay	E12	5
	C12	Mismatch model design	E13	4
		Programming error	E14	3
		Errors in machine use	E15	5
		Bad welding	E16	4
		Work accident	E17	3
		Errors in flange joining technique	E18	4
		Bending error	E19	4
		Incomplete processing of the powder coating	E20	3
		Incomplete processing of the enamel baking	E21	3
		Product malfunction	E22	2
Deliver	C13	Production size does not match demand	E23	2
	C14	Lack of transportation resources for product delivery	E24	3
		Damage to product items ordered	E25	3

Business Processes	Code	Risk Event	Code	Severity
Return	C15	Delay in product delivery	E26	3
	C16	Delay in handling defective product	E27	4
	C17	Unexpected costs for material handling	E28	1

Based on the risk events that have been identified, there are risk agents that will also be identified through an assessment of the level of potential sources of risk that can occur. The assessment was conducted through an interview with the production department expert at PT. Tamura Air Conditioning Indonesia. The following information shows the identification results of the risk agents that occurred at PT. Tamura Air Conditioning Indonesia.

Table 4.5. Risk Agent

Code	Risk Agent	Occurrence
A1	Invalid historical data input	3
A2	The number of changing/sudden requests from customers	2
A3	Programming error	2
A4	Scarcity of raw materials	2
A5	The contract/agreement with the supplier is not good	2
A6	Miss-communication between suppliers, warehouse staff, and Purchasing staff	3
A7	Raw material supplier negligence in delivery	2
A8	Purchase Order (PO) request calculation error	1
A9	Workers' negligence in implementing screening SOPs	2
A10	Lack of accuracy in product measurements	2
A11	Lack of performance of workers' skills	3
A12	Error in measuring the degree of curvature	2
A13	Machine error	3
A14	The person in charge of transportation is not careful enough to update delivery schedule information	3
A15	Limited transportation facilities	1
A16	Transport accidents during delivery	1
A17	Employee negligence in product inspection prior to delivery	2
A18	Insufficient handling of rejected products	2

4.2 Data Processing

4.2.1 House of Risk Phase 1

In House of Risk phase 1, an aggregate risk potential calculation is carried out which aims to find out the priority risks that will be given treatment or mitigation. Table 4.6 below shows a complete overview of the results from ARP calculations. With the formula as referred in equation (2.1), one example of the ARP calculation for ARP_1 is as follows:

$$ARP_j = O_j \sum S_i R_{ij}$$

$$ARP_1 = 3\begin{bmatrix} (4 \times 9) + (3 \times 9) + (3 \times 9) + (3 \times 3) \\ +(5 \times 9) + (5 \times 3) + (2 \times 9) + (1 \times 1) \end{bmatrix}$$

$$ARP_1 = 3[36 + 27 + 27 + 9 + 45 + 15 + 18 + 1]$$

$$ARP_1 = 534$$

Based on the results of data collection and processing in House of Risk phase 1, the following model for House of Risk phase 1 was obtained:

Table 4.6. House of Risk Phase 1

Risk Event (Ej)	**Risk Agent**																		**Severity (Si)**
	A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**	**A10**	**A11**	**A12**	**A13**	**A14**	**A15**	**A16**	**A17**	**A18**	
E1	9	1	9					1			9		3						4
E2	9	9		3	1	3	1			3		3	9	1	1	3			3
E3				9	9	9	3							3	1		1		3
E4		9	1	3		3													5
E5	9			9	3	9		9								9			3
E6		9		9	1	1					9		3						3
E7	3	3																	3
E8				3	1		9							3					4
E9	9	1				3		1			3					3			5
E10				9			1												2
E11									3		3		3						3
E12	3	9		3		1	3	1	1	1	3	1	9						5
E13						1			3	3	3	9	9						4
E14										9	3	1	3						3
E15									3		9		9						5
E16								1	3	3	9	3	1						4
E17									9		3		3						3
E18									3	3	9	3	9						4
E19									3	3	3	9	9						4
E20											9		9						3
E21											9		9						3
E22									9			1	3			9	9		2
E23	9	1	1										3						2
E24														3	9				3
E25											3		1			9	9		3
E26								3			3		1	9	3	9			3
E27											9							9	4
E28	1	3																9	1
Oj	3	2	2	2	2	3	2	1	2	2	3	2	3	3	1	1	2	2	
ARP	534	334	82	300	92	315	130	54	244	178	1107	230	1047	180	42	123	96	90	
Pj	3	4	16	6	14	5	11	17	7	10	1	8	2	9	18	12	13	15	

4.2.2 Risk Evaluation

Risk evaluation is a process that involves identifying the most important risk agents based on the total value of their potential risk. The risk agent with a higher aggregate risk potential value possesses a greater level of priority. The following table is the result of calculating the cumulative risk potential value:

Table 4.7. Calculation Results of Aggregate Risk Potential (ARP) Values

Risk Agent	ARP Value	ARP Cumulative	% ARP	% ARP Cumulative
ARP 11	1107	1107	21,4%	21%
ARP 13	1047	2154	20,2%	42%
ARP 1	534	2688	10,3%	52%
ARP 2	334	3022	6,5%	58%
ARP 6	315	3337	6,1%	64%
ARP 4	300	3637	5,8%	70%
ARP 9	244	3881	4,7%	75%
ARP 12	230	4111	4,4%	79%
ARP 14	180	4291	3,5%	83%
ARP 10	178	4469	3,4%	86%
ARP 7	130	4599	2,5%	89%
ARP 16	123	4722	2,4%	91%
ARP 17	96	4818	1,9%	93%
ARP 5	92	4910	1,8%	95%
ARP 18	90	5000	1,7%	97%
ARP 3	82	5082	1,6%	98%
ARP 8	54	5136	1,0%	99%
ARP 15	42	5178	0,8%	100%

According to the table above, the risk agents A11 and A13 have the highest Aggregate Risk Potential values of 1107 and 1047, respectively, indicating that they are the highest-priority risk agents. Once the risk prioritizing has been established, the next step is constructing the fishbone diagram and developing the mitigation strategy. This will help determine the most appropriate preventive action for the prioritized risk agent.

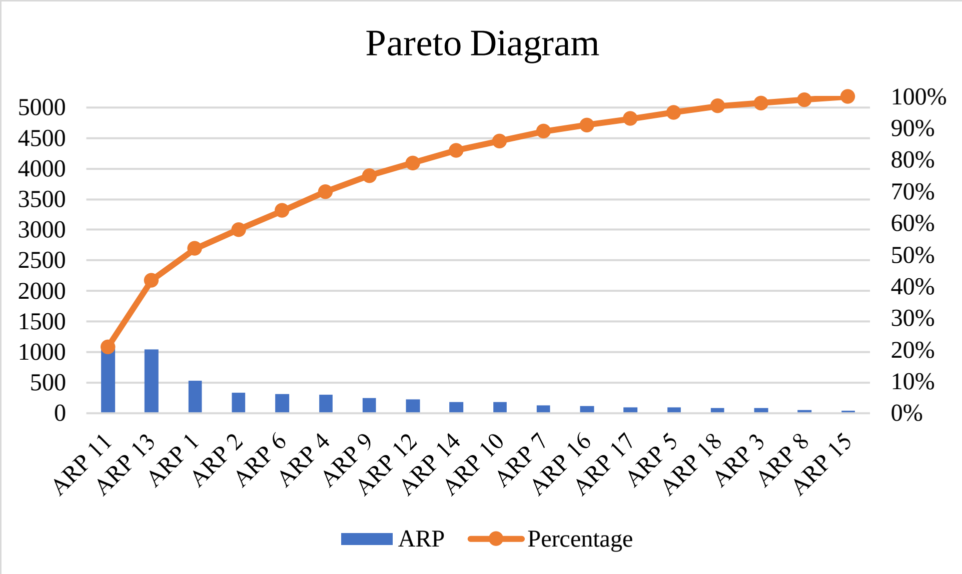

Figure 4.3. Pareto Diagram

Based on Figure 4.3 above, there are some of the most dominant risk agents that can be treated. In further discussion with the company, they requested to use two dominant risks to be evaluated in this research. Therefore, there are two dominant risk agents based on the Pareto diagram above which can be solved by designing a risk mitigation strategy according to these risk agents. Based on the Pareto concept, it is obtained that 20% of the main causal risk agents are expected to reduce the 80% of other risk agents. The two dominant risk agents are A11 and A13. The following is a table of the dominant aggregate risk potential values of the two risk agents.

Table 4.8. Risk Agent Dominant

Ranking	Code	Risk Agent	ARP	Oi	Si
1	A11	Lack of performance of workers' skills	1107	3	4
2	A13	Machine error	1047	3	3

The next step is to create a risk mitigation strategy using the House of Risk Phase 2 after obtaining the two dominant risk agents. Taking the risk appetite into consideration helps balance the company’s willingness to accept risk with the prioritization and management of identified risks in determining the most appropriate course of action to achieve supply chain resilience. Risk mapping will be handled first to illustrate the condition of the dominant risk agent before handling the treatment. The following are potential risks from dominant risk agents:

Table 4.9. Risk Map

Likelihood of Consequences	**Potential Consequences**				
	Insignificant **1**	**Minor** **2**	**Moderate** **3**	**Major** **4**	**Catastrophic** **5**
A (Almost Certain) 5					
B (Likely) 4					
C (Moderate) 3			**A13**	**A11**	
D (Unlikely) 2					
E (Rare) 1					

The risk mapping above is carried out based on the following levels:

Table 4.10. Risk Map Category

Potential Consequence	**Severity**	**Occurrence**
Insignificant	1	1
Minor	2	2
Moderate	3	3
Major	4	4
Catastrophic	5	5

4.2.3 House of Risk Phase 2

According to the risk assessments conducted using the House of Risk Phase 1 and the Pareto diagram, two risk agents were identified to be of the highest priority. After identifying two priority risk agents, each risk agent is analyzed using the fishbone diagram in the following form. Hence, an analysis of causes is conducted through the application of the fishbone diagram methodology in order gain a more informed conclusion about the design of a mitigation strategy. The fishbone diagram which demonstrates the most critical factor will be displayed in Figure 4.4 and 4.5 as follows.

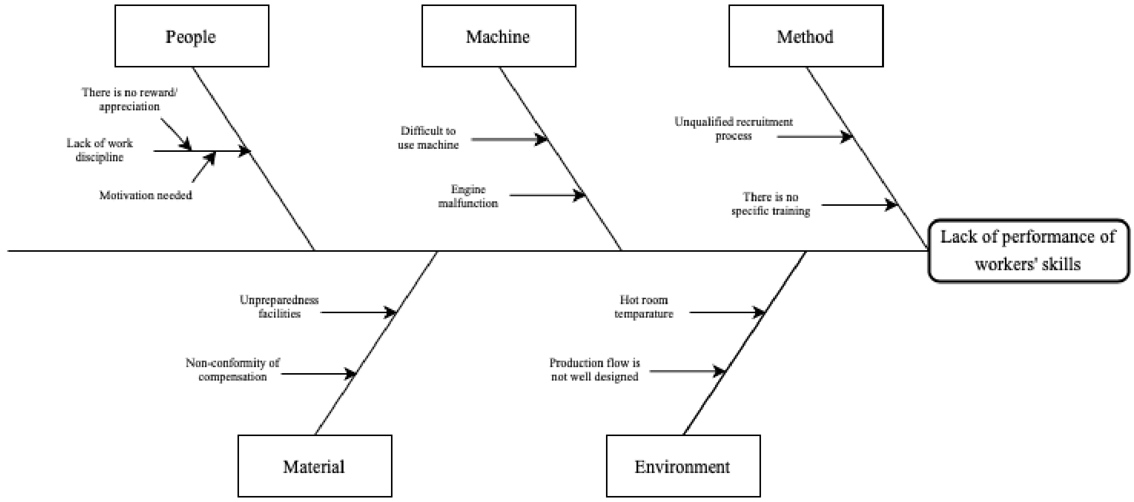

Figure 4.4. Fishbone Diagram (A11)

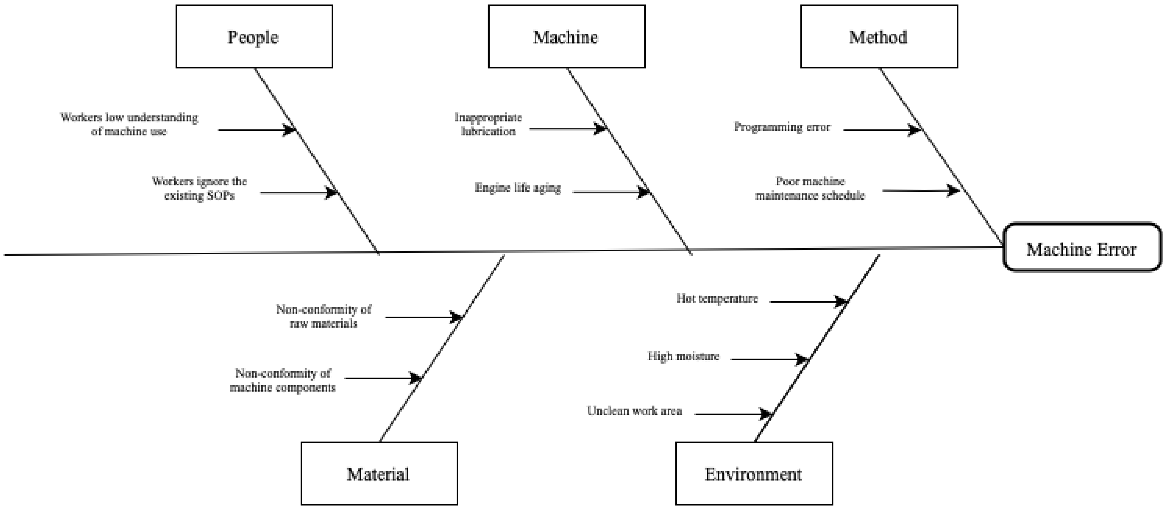

Figure 4.5. Fishbone Diagram (A13)

After conducting data processing in House of Risk Phase 1, the next step is House of Risk Phase 2 to identify the most effective risk mitigation strategy to minimize the likelihood of risk events based on risk agents.

As depicted in the Pareto diagram in Figure 4.3 above, two dominant risk agents will be addressed. The first step in creating a mitigation strategy is to determine the most appropriate mitigation measures for the selected risk agents. Based on both risk agents, 7 preventive actions have been designed. The following preventive actions were obtained from references from many sources and direct interviews with experts along with the consideration of the root cause identification using a fishbone diagram. The following table contains the preventive actions that were obtained from two different risk agents. The alternative mitigation strategy that can be taken by formulating preventive actions will be outlined in the table below:

Table 4.11. Preventive Action

No.	Risk Agent	Preventive Action	Code	Dk
1.	Lack of performance of workers' skills	Recruit and evaluate employees with good abilities and skills	PA1	5
		Create a healthy working environment	PA2	3
		Conduct evaluations of each department/individual	PA3	3
		Improve employee supervision	PA4	5
		Risk handling training for workers	PA5	5
2.	Machine error	Create SOPs for common machine checks	PA6	4
		Maintenance of machine equipment is carried out routinely	PA7	4

Furthermore, assessing the level of correlation, is the second stage in House of Risk 2 with the aim of determining the level of relationship that exists between the two variables. Similar to the previous House of Risk phase 1, this level correlation assessment is also carried out using a scale of 0, 1, 3, and 9. Then, after knowing the existing relationship, the total effectiveness (TE_k) value is calculated which is the third stage in the House of Risk phase 2 to determine the effectiveness value of the preventive action based on the correlation value that was given previously. With the formula as referred in the equation (2.2), one example of the TE_k calculation is as follows:

$$TE_k = \sum ARP_j \cdot E_{jk}$$

$$TE_1 = [(1107 \times 9) + (1047 \times 1)]$$

$$TE_1 = 11010$$

The Degree of Difficulty (Dk) assessment is also carried out to determine the level of difficulty in implementing each mitigation action that has been designed. The assessment is carried out using scales 3, 4, and 5. Again, scale 3 indicates the action is easy to implement, scale 4 indicates the action is rather difficult to implement, and scale 5 indicates the action is difficult to implement. Moreover, after obtaining the total effectiveness value of each action, the next step is to determine the total effectiveness value of the difficulty ratio to establish the effectiveness and difficulty ratio in carrying out each mitigation action. With the formula as referred in the equation (2.3), one example of the ETD_k calculation is as follows:

$$ETD_k = TE_k / D_k$$
$$ETD_1 = 11010/5$$
$$ETD_1 = 2202$$

Table 4.12 below shows a complete overview of a table that combines many different variables to determine the priority order of risk mitigation, including the dominant risk agents' data, aggregate risk calculations potential of the dominant risk agent, degree of difficulty determination, total effectiveness and effectiveness to difficulty calculation, to determine the priority order of risk mitigation. The following is the House of Risk Phase 2 table:

Table 4.12. House of Risk Phase 2

Risk Agent	**Preventive Action**							**ARP**
	PA1	**PA2**	**PA3**	**PA4**	**PA5**	**PA6**	**PA7**	
A11	9	3			9		3	1107
A13	1		1	3	9	9	9	1047
TE_k	11010	3321	1047	3141	19386	9323	12744	
D_k	5	3	3	5	5	4	4	
ETD_k	2202	1107	349	628	3877	2356	3186	
Priority Rank (R_k)	4	5	7	6	1	3	2	

Based on Table 4.12 above, the priority order for mitigation strategies is obtained based on the highest ETD_k value. Multiple preventive actions have been gathered through references from various sources and direct interviews with the experts, taking into consideration of the level of difficulty and effectiveness when implemented. The following is a table of priority rankings for mitigation strategies obtained through several references from various sources and direct discussions with experts based on House of Risk phase 2 preventive action calculations:

Table 4.13. Risk Mitigation Strategy Priorities

Code	**Preventive Action**	**Priorities**
PA5	Risk handling training for workers	1
PA7	Maintenance of machine equipment is carried out routinely	2

Code	Preventive Action	Priorities
PA6	Create SOPs for common machine checks	3
PA1	Recruit and evaluate employees with good abilities and skills	4
PA2	Create a healthy working environment	5
PA4	Improve employee supervision	6
PA3	Conduct evaluations of each department/individual	7

According to Table 4.13 above, risk-handling training for workers receives the highest ETD score among the seven mitigation techniques that will be put into action, indicating that it is a top priority for the company. Afterwards, regularly carry out the maintenance of machine equipment, create SOPs for common machine checks, recruit and evaluate employees with good abilities and skills, create a healthy working environment, improve employee supervision, and the final approach is to conduct evaluations of each department /individual.

CHAPTER V
DISCUSSION

5.1 Risk Identification Analysis

In this research, the process of identifying risk events is based on the SCOR model approach because this model can describe the detailed business processes that occur at PT. Tamura Air Conditioning Indonesia. As an initial stage before risk identification begins, supply chain activity mapping is carried out to determine the details of supply chain activities which are divided into five different processes. This process was carried out in collaboration with three company experts. In this business process there are 5 parts such as plan, source, make, deliver, and return which will be identified.

First, carrying out the “Plan”. This process relates to the strategic and operational planning within the supply chain, with the objective of planning various aspects of operations to guarantee the smooth, efficient, and responsive operations of the company’s supply chain. The production system is owned by PT. Tamura Air Conditioning Indonesia performs on a make-to-order system. This process begins with the plan supply chain, plan source, and plan make which contains seven activities: Identify, prioritize, and aggregate supply chain requirements, balance supply chain resources with supply chain requirements, establish and communicate supply chain plans, balance product resources with product requirements, establish sourcing plans, balance production resources with production requirements, and creating production plans. The common challenges encountered include errors in demand forecast calculations and unable to fulfill requests.

The second business process is “Source”. This Source Make-to-Order product process is the acquisition of necessary raw materials for company operations, involving the careful selection of suppliers to ensure the prompt delivery of high-quality supplies that meet the organization’s demands. This procedure is executed subsequent to the identification of the activities taking place at PT. Tamura Air Conditioning Indonesia. This process involves two activities: receiving the procurement of raw materials and verifying the raw materials from suppliers. For the procurement process detail, PT. Tamura Air Conditioning Indonesia goes through several stages, starting from identifying the goods or services that the company needs, submitting purchase requests, finding and selecting suppliers or vendors, and negotiating prices. After the deal, a purchase order (PO) is made. Receiving and checking the suitability of the goods that have been received are also carried out and ensure the conformity between the purchase order, shipping documents, and the invoice received before making a payment. After payment is made, the company also records the entire history of the procurement process. Apart from that, the materials used were obtained from PT. Fumira, Cibitung, Bekasi Regency, which produced color-coated galvanized steel sheets in the original design of the Color Coating Line in 1979 and the company became one of the largest galvanized steel sheet manufacturers in Indonesia.

The third business process is “Make”. This process is a product manufacturing process that aims to convert raw materials into finished products according to consumer demand. In this Make-to-Order process there are three activities that occur, namely scheduling production activities, production process and the test, as well as release the finished product to deliver. In the production process, the production process includes the entire product manufacturing flow starting from raw materials to the final product that can be used according to its function, where the flow includes the planning design, making designs using CNC plasma machines, metal molding (double), aluminum welding, bending, pressing (cross duct expose), powder coating, and enamel baking. Production control includes planning, supervision, control, and evaluation related to production processes and results.

The fourth business process is “Deliver”. Specifically, Deliver Make-to-Order Product is the process of sending the final product to consumers with the aim of ensuring that the product is received by customers on time, in good condition, and in accordance with consumer needs and expectations. In this research, there are two activities that occur at PT. Tamura Air Conditioning Indonesia, namely loads the product & generate shipping docs, and shipping the product to customers. Considering that the production products ordered by customers are usually in large quantities so they are quite heavy, the delivery process is carried out independently by the company using company-owned transportation without collaborating with other logistics services. Apart from that, it is not only the company that delivers products to consumers but some consumers take their own ordered products to the company.

The last business process is “Return”. This process is the process of managing returns of products sent to customers with the aim of managing returns efficiently, minimizing losses, and ensuring customer satisfaction during the return process. There are two sub-processes namely Source Return Defective Product and Return Defective

Product. There are three activities in this process, the first is to identify defective product condition, schedule defective product shipment, and transfer defective product. Product returns from customers occur when the final product received by the customer does not match the expectations and order agreement that has been made between the customer and the company. In this case, the activities involved include identifying the condition of the product and requesting authority to return the defective product. Product handling activities usually include handling re-production, scheduling product returns to customers, and making returns by sending them to customers.

5.2 Risk Event and Risk Agent Analysis

The process of identifying risk events and risk agents was carried out through an interview with the production department experts at PT. Tamura Air Conditioning Indonesia. The risk event assessment was conducted by distributing a questionnaire to experts. The selected experts consist of two assistant managers specializing in different fields, as well as one member of the purchasing staff. Risk event identification is conducted in order to determine potential risk events that may arise at PT. Tamura Air Conditioning Indonesia. The process of identifying risk agents is conducted to determine the root causes of a risk. Through interviews and questionnaires, a risk identification and scoring process was established to assess the severity and occurrence levels. As a result, 28 risk events and 18 risk agents were identified that could potentially occur in the business process of PT. Tamura Air Conditioning Indonesia.

During the “Plan” process, there are three sub-processes namely Plan Supply Chain, Plan Source, and Plan Make. In Plan Supply Chain, there are three activities labeled C1, C2, and C3. Plan Source with two activities labeled as C4 and C5, also Plan Make with two activities as well labeled as C6 and C7. Additionally, there are seven risk events labeled as E1, E2, E3, E4, E5, E6, and E7. The severity values obtained for these events are 4, 3, 3, 5, 3, 3, and 3, respectively. Within the process “Source”, specifically for the Make-to-Order Product, there are two activities labeled C8, C9, and C10. Additionally, there are three risk events labeled as E8, E9, and E10. The severity values obtained for these events are 4, 5, and 2, respectively. During the “Make” process specifically for Make-to-Order business process, there are two activities labeled C11 and C12. Additionally, there are thirteen risk events labeled as E11, E12, E13, E14, E15, E16, E17, E18, E19, E20, E21, E22, and E23. The severity values obtained for these events were 3, 5, 4, 3, 5, 4, 3, 4, 4, 3, 3, 3, and 2, respectively. During the "Deliver" process, specifically in Deliver Make-to-Order product, there are two activities labeled as C13, C14, and C15, followed by four risk events, labeled as E23, E24, E25, and E26. The severity values obtained for these events were 2, 3, 3, and 3, respectively. During the "Return" process, there are two sub-processes existed namely, Source Return Defective Product and Return Defective Product. In Source Return Defective product, the activity that was identified as C16 with a risk event labeled as E27. The severity value obtained is 4. Also, for the Return Defective Product, there is only one activity that labeled as C17 with 1 risk event labeled as E28 with severity value of 1.

For risk agents that may cause risks to occur in the company's supply chain activities include invalid historical data input (A1) with an occurrence score of 3, the number of changing/sudden requests from customers (A2) with an occurrence score of 2, programming errors (A3) with an occurrence score of 2, scarcity of raw materials (A4) with an occurrence score of 2, the contract/agreement with the supplier is not good (A5) with an occurrence score of 2, miss-communication between suppliers, warehouse staff, and purchasing staff (A6) with an occurrence score of 3, raw material supplier negligence in delivery (A7) with an occurrence score of 2, purchase order (PO) request calculation error (A8) with an occurrence score of 1, workers' negligence in implementing screening SOPs (A9) with an occurrence score of 2, lack of accuracy in product measurements (A10) with an occurrence score of 2, lack of performance of workers' skills (A11) with an occurrence score of 3, error in measuring the degree of curvature (A12) with occurrence score of 2, machine error (A13) with an occurrence score of 2, the person in charge of transportation is not careful enough to update delivery schedule information (A14) with an occurrence score of 3, limited transportation facilities (A15) with an occurrence score of 1, transport accidents during delivery (A16) with an occurrence score of 1, employee negligence in product inspection prior to delivery (A17) with an occurrence score of 2, and insufficient handling of rejected products (A18) with an occurrence score of 2.

5.3 Risk Priority Analysis

House of Risk is a method that combines the Failure Mode and Effect Analysis (FMEA) method with the House of Quality (HOQ) method. During HOR phase 1, the priority level of risk agents as preventative actions to be implemented is determined. As shown in Table 4.6 above, the identification of dominant risk agents is based on the value of Aggregate Risk Potential (ARP), which involves the severity, occurrence, and correlation of each risk agent.

In this research, the concept of the Pareto diagram utilized is the 80:20 principle, which signifies that by addressing 20% of the prioritized risk agents, it is expected to improve 80% of the remaining risk agents. As previously stated, the determination of priority risk is based on the aggregate risk potential value possessed by each risk agent. As the value increases, the risk agent becomes more prioritized. However, not all risk agents will receive treatment or mitigation actions in risk management due to other factors that need to be considered more deeply, such as the influence of the risk on recurring issues, the scale of the impact it will cause, and the cost that will be incurred. Therefore, further discussions were conducted with all experts, and it was decided that out of the 17 identified risk agents, two dominant risk agents were selected based on their top-ranking positions. These are risk agent A11, corresponding to the lack of performance of workers' skills, and risk agent A13, corresponding to the machine errors that play a major role in the production process at PT. Tamura Air Conditioning Indonesia.

Furthermore, risk mapping also helps to prioritize which risk agent will be addressed first in order to assess the condition of the dominant risk agent prior to implementing treatment. According to Table 4.9, A11 is classified in the red color zone while A13 is classified in the orange color zone that indicates the high and significant level of risk. In the risk appetite criteria, red and orange are threat/risk areas that must be controlled because it is unacceptable. This implies that prompt mitigation actions should be immediately taken. Based on the results of Figure 4.7 above, a value of 42% is selected as the risk agent to be given a mitigation strategy with the expectation of minimizing the remaining other risk agents. The following are the dominant risk agents obtained:

1. Lack of performance of workers' skills (A11)

   The first risk agent that will be addressed with mitigation actions is the lack of performance of workers' skills (A11), with an aggregate risk potential value of

1107, representing 21,4% of the total overall risk agents. Workers are a crucial factor in ensuring the smoothness of the production process, given that PT. Tamura Air Conditioning Indonesia still relies on human assistance for its production. Therefore, if there is a lack of performance in workers' skills, it will certainly have an impact on the quality of the final product produced. The negligence of this worker is the primary cause of the emerging risks. There are 17 risk events caused by the lack of performance of workers' skills. These include errors in demand forecast calculations, unpreparedness of production facilities, delay in arriving raw materials, insufficient quantity of incoming raw materials, errors in production process scheduling plans, mismatch model design, programming error, errors in machine use, bad welding, work accident, errors in flange joining technique, bending error, incomplete processing of the powder coating, incomplete processing of the enamel baking, production delay, delay in product delivery, damage to product items ordered, and delay in product handling.

2. Machine error (A13)

   The second risk agent that will be addressed with mitigation actions is machine error (A13), with an aggregate risk potential value of 1047, representing 20,2% of the total risk agents. The presence of heavy machinery used in the production process at PT. Tamura Air Conditioning Indonesia makes the machinery one of the main contributors to producing high-quality products. In this situation, workers are required to have proficient knowledge and abilities in the maintenance and operation of machinery. After discussions with experts, it was clearly decided that these two risk factors are definitely the most dominant and critical problems that require immediate action at this company. There are 18 risk events caused by machine error. These include errors in demand forecast calculations, unable to fulfill requests, unpreparedness of production facilities, errors in production process scheduling plans, mismatched model design, programming errors, errors in machine use, bad welding, work accidents, errors in flange joining technique, bending error, incomplete processing of the powder coating, incomplete processing of the enamel baking, production delay, production size does not match demand, product malfunction, delay in product delivery, and damage to product items ordered.

5.4 Fishbone Diagram Analysis

By determining the percentages presented on the Pareto diagram, the root causes were analyzed through the use of a fishbone diagram. There are five aspects that could contribute to the cause of this incident: people, machines, methods, materials, and environment. The aspects related to the risk problem at PT. Tamura Air Conditioning Indonesia illustrated in Figures 4.5 and 4.6 will be discussed in the following Table.

1. Risk Agent (A11)

   The risk agent A11, which concerns the "lack of performance of workers' skills", is analyzed through the use of a fishbone diagram. The first aspect is related to the people. People in PT Tamura Air Conditioning Indonesia are workers who actively participate in the production process. The role of people significantly impacts the quality of the product as they are responsible for completing all tasks associated with the production process. The main cause of this issue is the lack of work discipline, which stems from the absence of appreciation/ rewards due to their concerns over meeting output goals. Hence, it is suggested that this issue could be solved by the creation of a healthy work environment and the implementation of comprehensive assessments for each department/individual, which allows the documentation of worker performance or allegiance as evaluations and achievements in the future.

   Machines, as a second aspect, serve as production instruments that facilitate workers activities. An influencing aspect refers to the situation in which the machine goes through a malfunction, leading to its inability to perform correctly. In addition, the utilization of complicated machinery significantly reduces worker's productivity due to all of the steps involved in operating such machines. The proposed approach involves performing regular maintenance on machinery equipment, developing standard operating procedures (SOPs) for common machine checks, and recruiting skilled people.

   In the context of a method, it refers to a specific set of instructions or tasks that need to be followed. The main problem with this approach is in the insufficient expertise and qualifications of potential candidates during the hiring process, coupled with the absence of a specific training program aimed at improving workers' understanding. The most suitable strategy is the recruitment and assessment of personnel with exceptional talents and skills, along with the provision of risk management training to improve their proficiency and promptness in handling specific circumstances.

The fourth aspect is related to materials. Materials include all tangible assets utilized by the company in the production process. Possible consequences are inadequate preparation of facilities, low-quality raw materials, and failure to provide fair compensation for workers. Hence, the acceptable course of action to be undertaken is to improve employee supervision.

The fifth aspect is the environment. The environment is the conditions around the company that directly or indirectly affect the company in general and can influence the production process. The environmental impact on worker's performance is caused by excessively high temperatures, with the average temperature in Cikarang area reaching 25,7°C. These elevated temperatures result in excessive sweating among operators and adversely interfere with their concentration in the workplace. In addition, the lack of proper organization in the production flow contributes to an uncomfortable production space. This, in turn, leads to distractions for workers and negatively impacts their productivity, resulting in numerous errors across the production process. To address this issue, the company could start by enhancing ventilation systems to ensure optimum air circulation.

2. Risk Agent (A13)

The risk agent A13, which concerns to the "machine error" is analyzed using the fishbone diagram as shown below. The first aspect related to the people part. Machine errors can be influenced by workers' poor skills and understanding of operating existing machinery, as well as their lack of expertise or disobedience for implement the existing Standard Operating Procedures (SOPs).

Machines, as a second aspect, serve as production instruments that facilitate workers activities. The factors that matter in this context are situations when the engine lacks enough lubrication, and the natural deterioration of the engine over time, which can both negatively impact its performance. Hence, regular checks of the instrumentation and its components is needed.

The third aspect is method. Method refers to a specific set of instructions or tasks that need to be followed. The root cause of this machine error is a programming error, as it is clear that certain machines rely on coding and programming technologies. In addition, an improper machine maintenance schedule might have negative effects on the productivity of the machine.

The fourth aspect is related to material. Factors that might impact are the lack of conformity of raw materials and the necessity for thorough inspections to ensure the quality of raw materials aligns with the company's standard requirements. In addition, the lack of confirmation of machine components also has an impact on the quality of the product, requiring thorough inspections to ensure that component quality aligns with company specifications.

The fifth aspect is the environment. The environment is the conditions around the company that directly or indirectly affect the company in general and can influence the production process. Hot temperatures, excessive humidity, and chaotic workplaces are influential factors that can affect machine and worker activity. Furthermore, there is a requirement for additional ventilation and lighting. Additionally, the implementation of improvements to the 5R culture can guarantee a higher level of comfort throughout activities.

5.5 Mitigation Action Design Analysis

In order to minimize potential risks, it is necessary to implement alternative proposed treatments or mitigation actions. Based on the identified dominant risk agents, mitigation actions will be defined, which may then be carried out after an in-depth analysis. The analysis is conducted by an in-depth review of references in academic journals, analysis using a fishbone diagram, and engaging in discussions with experts to verify the relevance and feasibility of the proposed mitigation actions.

Chapman (Chapman, 1979) was the first to introduce the idea of secondary risk, and he developed a comprehensive risk management system that included risk assessment as well as treatment. This is the first study to address secondary risks, proving that these risks should be identified after primary response activities have been done, as secondary risks occur as a direct result of implementing a specific risk response. Similarly, in proposing this approach as the most appropriate way to determine mitigation actions for risk management, this research also provides secondary risk as the further analysis regarding the potential outcomes from implementing the proposed mitigation actions by analyzing the positive and negative impact for a more comprehensive risk response strategy analysis.

This risk mitigation strategy was developed from House of Risk phase 2. In HOR phase 2, the mitigation strategies are arranged based on their ETD value, from highest to lowest. The variables used to determine the effectiveness of the handling are the level of difficulty (Degree of Difficulty) and the correlation between risk agents. From the two dominant risk factors, the research identifies seven strategies for treatment or mitigation actions. An analysis was performed on the ETD values of the seven different mitigation actions. The order of significance for implementing the suggested preventative actions can be seen in Table 4.13 above. Below are the mitigation strategies alternatives that can be implemented by PT. Tamura Air Conditioning Indonesia:

a. The first strategy is to conduct risk-handling training for workers (PA5) with an ETD value of 3877, because it is an important aspect of workplace safety. This can also be used to develop a risk management plan and provide workers with how to handle potential hazards during the production process.
b. The second strategy is to pay more attention to the maintenance of machine equipment so that it is carried out routinely (PA7) and it does not hamper the entire production process. With an ETD value of 3186, if this preventive action is taken, it can help ensure the function and safety of machines in the workplace.
c. The third strategy is to create SOPs for common machine checks (PA6) with an ETD value of 2356. Implementing this technique will result in cost reduction for machine maintenance and potential improvement of overall machine performance, hence benefiting the organization.
d. The fourth strategy is to recruit and evaluate employees with good abilities and skills (PA1) with an ETD value of 2202. Although challenging, this effort certainly will increase the company's worth and improve manufacturing outcomes with better quality.
e. The fifth strategy is to create a healthy working environment (PA2) with an ETD value of 1107. Good lighting and ventilation, open and honest communication,

mutual respect, and other similar working practices can help put this strategy into action.

f. The sixth strategy is to improve employee supervision (PA3) with an ETD value of 628. Improvement. This worker supervision can be done by using monitoring technology, creating measurable key performance indicators, supporting workers with coaching, as well as recognizing and appreciating fellow workers.

g. The seventh strategy is to conduct evaluations of each department/individual (PA4) with an ETD value of 349. Open communication from various points of view, including supervisors to workers, workers to department heads, and vice versa, can enhance a company's credibility and trustworthiness. It is crucial to conduct this review fairly and straightforwardly.

For a more comprehensive risk mitigation strategy, the secondary risk also has been analyzed based on the two proposed major mitigation actions that have been prioritized. The following is the activity that PT. Tamura Air Conditioning Indonesia is able to put into action.

Table 5.1. Mitigation Action Design with Secondary Risk

No.	Mitigation Action	Secondary risk	
		Positive Impact	**Negative Impact**
1.	Risk handling training for workers (PA5) • Conduct Basic K3 training program for production staff. • Conduct risk management training programs (CRMO & CRMO). • Review and updating training program 2-3 times a year.	• Empower worker to more easily identify and adapt to changes in the workplace. • The way the worker handling risk is structured and confidently. • Make workers aware and pay more attention to the SOPs to avoid work accidents.	• Some workers may think training can disrupt existing routines. • The worker may become complacent for certain risk because they are fully prepared. • Consuming work hours.
2.	Maintenance of machine equipment is carried out routinely (PA1) • Create detail SOPs to Monitor the performance of each equipment. • Maintain spare parts stock. • Plan the emergency response.	• Can reduce the maintenance cost before the cost escalate into costly total repair. • Extends its lifespan. • Reduces the possibility of major failures. • Operational reliability and productivity increased.	• If this maintenance action is not optimal or if unexpected issues arise during servicing, it can add up over time and strain the company’s budget. • Production delays and missed deadlines.

CHAPTER VI
CONCLUSION & SUGGESTION

6.1 Conclusion

According to the results of the analysis and data processing, the following conclusions are obtained:

1. The identified risk events that could affect the quality of finished goods in the production process at PT. Tamura Air Conditioning Indonesia turned out to be 28 risks with 18 risk agents. However, the company must prioritize managing the dominant risk agents among 28 different risk events to ensure the safety, efficiency, and quality of finished goods from the process. Thus, the research results show that the most dominant causes of risk here are lack of performance of workers' skills (A11) and machine error (A13).
2. The most suitable strategy to be applied for PT. Tamura Air Conditioning Indonesia minimizes its risks by providing risk-handling training for workers (PA5), paying more attention to the maintenance of machine equipment so that it is carried out routinely (PA7), creating SOPs for common machine checks (PA6), recruiting and evaluating employees with good abilities and skills (PA1), creating a healthy working environment (PA2), improving employee supervision (PA4), and to conduct evaluations of each department/individual (PA3).

6.2 Suggestion

Based on the limitations of the scope of the study and the conclusions regarding the analysis of the causes of risk and risk mitigation for PT. Tamura Air Conditioning Indonesia, some suggestions could be obtained for this research that will be described as shown below:

1. For the company.

   Suggestions for companies are to be able to implement and consider the main mitigation strategy proposals given and to be able to pay close attention to and make improvements to risks that may occur to avoid losses and minimize risks.

2. For further research.
    - Suggestions for further research are to make a schedule for the implementation of the main risk mitigation strategy to find out the changes that occur after the implementation of the main risk mitigation strategy.
    - Gain more detailed information in identifying risk events and risk agents by getting more intensive information about all elements at the Production Department.

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APPENDIX

A-HOR Phase 1 Assessment

RISK ASSESSMENT HOR PHASE 1

Assalamualaikum Wr. Wb.

Perkenankan saya, N. Shafira Meilina, mahasiswi jurusan Teknik Industri Internasional Program Universitas Islam Indonesia. Dengan kuesioner ini, saya meminta kesediaan Bapak/Ibu untuk turut berpartisipasi dalam mengisi kuesioner ini. Kuisioner ini digunakan untuk menyusun penelitian Tugas Akhir saya yang berjudul *"Designing Risk Mitigation in Supply Chain Management with Supply Chain Operational Reference (SCOR) Approach using House of Risk (HOR) Method"*. Saya ucapkan terima kasih atas waktu dan kesediaan Bapak/Ibu, besar harapan saya agar penelitian ini dapat bermanfaat bagi kami, perusahaan, dan untuk penelitian selanjutnya.

Data Responden

Nama :

Umur :

Jabatan :

Lama Kerja :

A. Penilaian *Severity* (Tingkat Keparahan) Risiko

Setiap aktivitas rantai pasok di PT XYZ telah diidentifikasi dan diketahui masing-masing *risk event* (risiko kejadian). Pada tahapan ini, *risk event* (risiko kejadian) akan dinilai oleh *expert / risk owner* berdasarkan nilai *severity* (tingkat keparahan). Berikut adalah panduan pengisian kuisioner penilaian *risk event* (risiko kejadian) berdasarkan skala dari nilai *severity* (tingkat keparahan):

Ranking	Keparahan	Deskripsi	Kiteria		
			Success Level	Product Quality	Financial Loss
1	*Insignificant*	Tidak berpengaruh	Keberhasilan projek sebesar 96%-100%	Kecacatan dari total produksi sebesar <1%	Kerugian dari pendapatan sebesar < 5%
2	*Minor*	Risiko menimbulkan gangguan sedikit	Keberhasilan projek sebesar 91%-95%	Kecacatan dari total produksi sebesar 1-10%	Kerugian dari pendapatan sebesar 5-10%

A-HOR Phase 1 Assessment (cont'd)

Ranking	Keparahan	Deskripsi	Kiteria		
			Success Level	**Product Quality**	**Financial Loss**
3	*Moderate*	Risiko menimbulkan gangguan rendah	Keberhasilan projek sebesar 86%-90%	Kecacatan dari total produksi sebesar 11-20%	Kerugian dari pendapatan sebesar 11-15%
4	*Major*	Risiko menimbulkan gangguan besar	Keberhasilan projek sebesar 81%-85%	Kecacatan dari total produksi sebesar 21-30%	Kerugian dari pendapatan sebesar 16-20%
5	*Catastrophic*	Risiko menimbulkan gangguan berbahaya dan kegagalan tidak diketahui dengan peringatan	Keberhasilan projek sebesar ≤ 80%	Kecacatan dari total produksi sebesar > 30%	Kerugian dari pendapatan sebesar > 20%

Risk Event	**Kode**	***Severity* (Tingkat Keparahan)**
Kesalahan dalam perhitungan perkiraan permintaan	E1	
Tidak dapat memenuhi permintaan	E2	
Kurangnya informasi antara sesama perencana *supply shain*	E3	
Ketidakpastian permintaan dari *customer* di waktu bersamaan	E4	
Kesalahan dalam perencanaan pengadaan bahan baku material	E5	
Ketidaksiapan fasilitas produksi	E6	
Kesalahan dalam rencana penjadwalan proses produksi	E7	
Terlambatnya bahan baku material yang datang	E8	
Kurangnya jumlah bahan baku yang datang	E9	
Kualitas bahan baku material yang tidak memenuhi standar	E10	
Alur proses produksi kurang terorganisasi dan terlihat berantakan	E11	
Produksi terhambat	E12	
Desain model yang tidak sesuai	E13	
Terjadinya kesalahan pemograman	E14	
Kesalahan dalam penggunaan mesin	E15	
Pengelasan yang buruk	E16	
Terjadinya kecelakaan kerja	E17	
Kesalahan teknik penggabungan *flanges*	E18	
Kesalahan dalam proses *bending*	E19	
Proses yang tidak menyeluruh pada proses *powder coating*	E20	
Proses yang tidak menyeluruh pada proses *eenamel baking*	E21	

A-HOR Phase 1 Assessment (cont'd)

Risk Event	**Kode**	***Severity*** **(Tingkat Keparahan)**
Kerusakan pada hasil produksi	E22	
Jumlah hasil produksi tidak sesuai dengan permintaan	E23	
Kurangnya sumber daya transportasi untuk pengiriman produk	E24	
Kerusakan *item* produk yang dipesan	E25	
Keterlambatan penagiriman produk	E26	
Keterlambatan dalam penanganan produk cacat	E27	
Ada tambahan biaya lain	E28	

B. Penilaian *Occurrence* (Tingkat Kejadian) Risiko

Setiap aktivitas rantai pasok di PT XYZ telah diidentifikasi dan diketahui masing-masing *risk event* (risiko kejadian. Kemudian *risk agent* (sumber risiko) yang menjadi penyebab adanya *risk event* (risiko kejadian) juga telah teridentifikasi. Pada tahapan ini, *risk agent* (sumber risiko) akan dinilai oleh *expert / risk owner* berdasarkan nilai *occurence* (tingkat kejadian). Berikut adalah panduan pengisian kuisioner penilaian *risk agent* (sumber risiko) berdasarkan skala dari nilai *occurence* (tingkat kejadian):

Number of Occurrence Rating			
Rating	**Probabilitas**	**Deskripsi**	**Kriteria**
1	*Rare*	Hampir tidak ada kegagalan yang terjadi	≤2 times/ 3 months
2	*Unlikely*	Kemungkinan kegagalan terjadi sesekali rendah	3-5 times/ 3 months
3	*Moderate*	Kemungkinan kegagalan terjadi sedang	6-8 times/ 3 months
4	*Likely*	Jumlah kegagalan tinggi terjadi	8-10 times/ 3 months
5	*Almost Certain*	Hampir pasti terjadinya kegagalan	> 10 times/ 3 months

Risk Agent	**Kode**	***Occurrence*** **(Tingkat Kejadian)**
Peng*input*an data histori yang tidak *valid*	A1	
Jumlah permintaan yang berubah-ubah/mendadak dari customer	A2	
Kesalahan pemograman	A3	
Kelangkaan bahan baku	A4	
Kontrak/persetujuan dengan supplier kurang baik	A5	
Miss-communication antara *supplier*, *staff* gudang, dan *staff Purchase Order* (PO)	A6	

A-HOR Phase 1 Assessment (cont'd)

Risk Agent	**Kode**	***Occurrence*** **(Tingkat Kejadian)**
Kelalaian *supplier* bahan baku dalam pengiriman	A7	
Kesalahan perhitungan permintaan *Purchase Order (PO)*	A8	
Kelalaian pekerja dalam menerapkan SOP *screening*	A9	
Kurangnya akurasi dalam pengukuran produk	A10	
Kurangnya performa keterampilan pekerja	A11	
Kesalahan dalam pengukuran derajat lengkung	A12	
Mesin error	A13	
Penanggung jawab transportasi kurang teliti untuk update informasi jadwal pengiriman	A14	
Keterbatasan sarana transportasi	A15	
Kecelakaan transportasi pada saat pengiriman	A16	
Kelalaian pekerja dalam inspeksi produk sebelum pengiriman	A17	
Kurangnya penanganan produk yang ditolak	A18	

A-HOR Phase 2 Assessment

RISK ASSESSMENT HOR PHASE 2

Assalamualaikum Wr. Wb.

Perkenankan saya, N. Shafira Meilina, mahasiswi jurusan Teknik Industri Internasional Program Universitas Islam Indonesia. Dengan kuesioner ini, saya meminta kesediaan Bapak/Ibu untuk turut berpartisipasi dalam mengisi kuesioner ini. Kuisioner ini digunakan untuk menyusun penelitian Tugas Akhir saya yang berjudul *"Designing Risk Mitigation in Supply Chain Management with Supply Chain Operational Reference (SCOR) Approach using House of Risk (HOR) Method"*. Saya ucapkan terima kasih atas waktu dan kesediaan Bapak/Ibu, besar harapan saya agar penelitian ini dapat bermanfaat bagi kami, perusahaan, dan untuk penelitian selanjutnya.

Data Responden

Nama :

Umur :

Jabatan :

Lama Kerja :

A. Identifikasi Strategi Mitigasi Risiko

Mitigasi risiko adalah suatu upaya untuk mengurangi risiko. Hal ini dilakukan untuk mengurangi dampak yang dapat merugikan maupun membahayakan Perusahaan. Risiko dominan juga telah di tentukan berdasarkan perhitungan nilai *Aggregate Risk Potential* (ARP). Pada tahap ini, *Degree of Difficulty* (skala kesulitan) akan dinilai dan ditentukan untuk masing masing strategi mitigasi risiko. *Degree of Difficulty* (skala kesulitan) merupakan tingkat kesulitan dari suatu penanganan untuk sumber risiko apabila akan dilakukan. Berikut adalah petunjuk untuk penilaian *Degree of Difficulty* (skala kesulitan):

Skala/Bobot	Keterangan
3	Aksi mitigasi mudah diterapkan
4	Aksi mitigasi cukup sulit diterapkan
5	Aksi mitigasi sulit diterapkan

Kode	Mitigasi	***Degree of Difficulty*** **(skala kesulitan)**
PA1	Merekrut dan mengevaluasi karyawan yang memiliki kemampuan dan keterampilan yang baik	
PA2	Menciptakan lingkungan kerja yang sehat	
PA3	Melakukan evaluasi terhadap masing-masing departemen/individu	
PA4	Meningkatkan pengawasan karyawan	
PA5	Mengadakan pelatihan *risk handling* bagi pekerja	
PA6	Membuat SOP untuk pemeriksaan mesin yang umum digunakan	
PA7	Perawatan peralatan mesin/ *sparepart* dilakukan secara rutin